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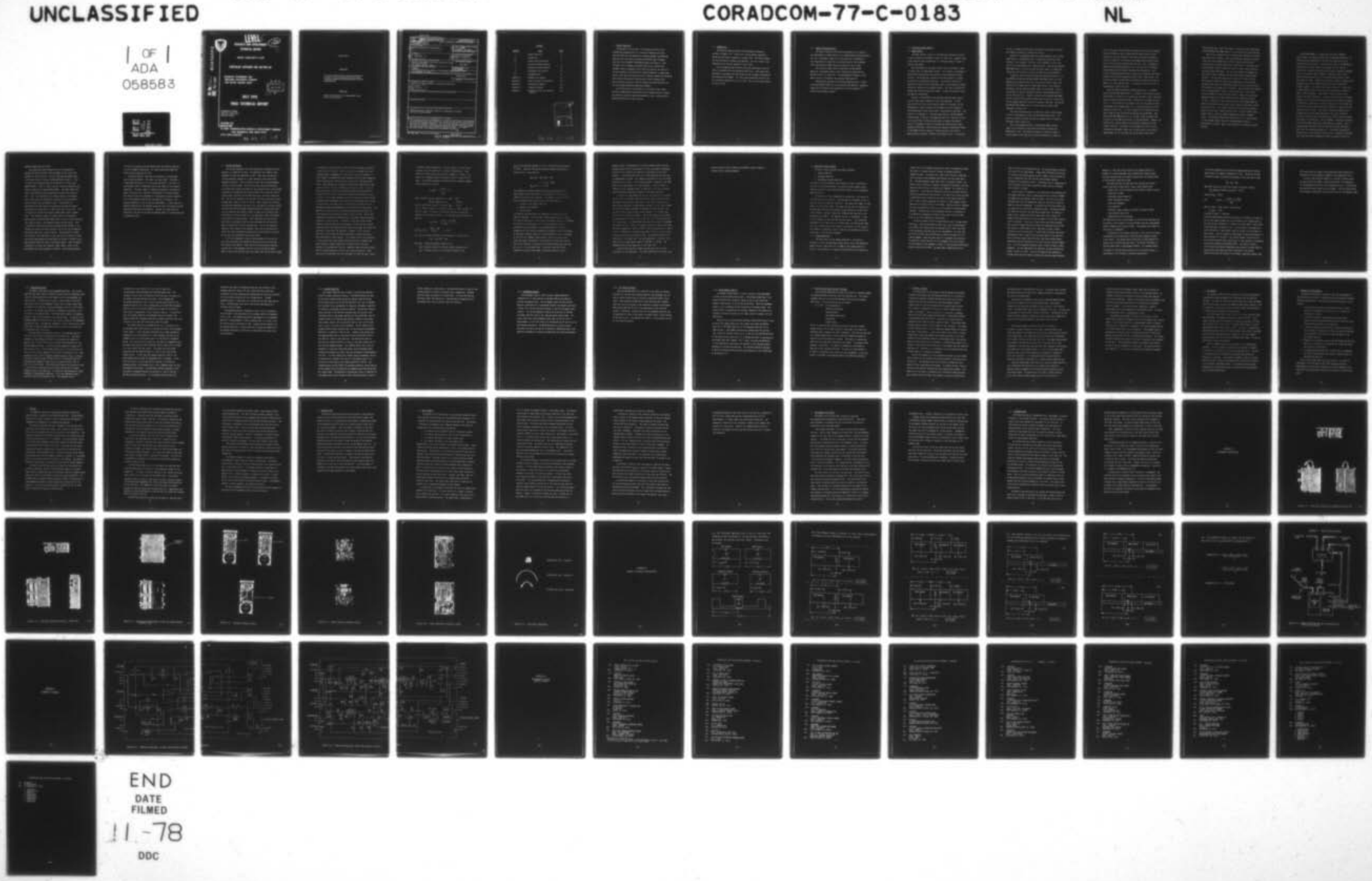

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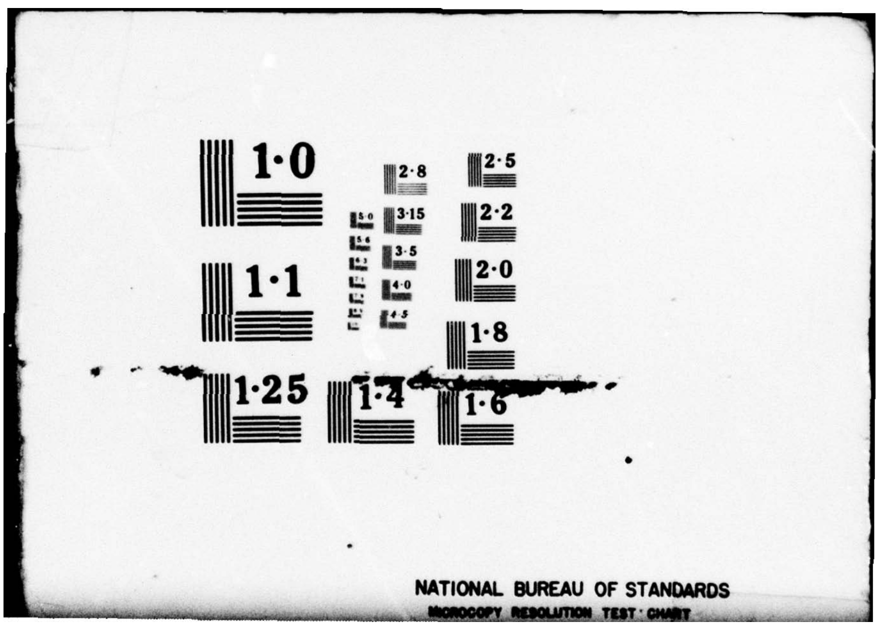
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RESEARCH AND DEVELOPMENT

TECHNICAL REPORT

REPORT CORADCOM-77-C-0183

VEHICULAR APPLIQUE FOR AN/PRC-68

MAGNAVOX GOVERNMENT AND
INDUSTRIAL ELECTRONICS COMPANY
FORT WAYNE, INDIANA 46808

JULY 1978

FINAL TECHNICAL REPORT

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This project covers the development of a vehicular applique to allow operation of the AN/PRC-68 radio set from within certain tactical vehicle, particularly the M-109 self-propelled howitzer. The vehicular applique provides an interface with the vehicular intercom system, an audio amplifier and a loudspeaker and uses the vehicular power system to operate the radio. Six models were constructed and subjected to environmental testing.

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CONTENTS

I. PROJECT OBJECTIVE

The purpose of this project is to design and build six (6) engineering prototype units of a Vehicular Applique unit which provides electrical and mechanical interface between the AN/PRC-68 Radio Set and the vehicular mounted AM-1780/VRC Audio Frequency Amplifier and C-2298/VRC Intercommunications Set Controls. Also included in this program as hardware items are an antenna base assembly, which accommodates the AT-892 tape antenna, and mounts to the cab bulkhead of the M-109 Self Propelled Howitzer, a power-audio control cable which provides electrical interface between the AN/PRC-68 Radio Set and the Vehicular Applique Unit, and an antenna cable which provides electrical interface between the AN/PRC-68 Radio Set and the bulkhead mounted antenna base assembly.

The ultimate goal of the program is to provide a short range vehicular communications system which can be operated with or without the vehicular intercom system when mounted in open or enclosed self-propelled howitzers or other vehicles.

II. PROGRAM PLAN

The Vehicular Applique design and development program was started in October 1977. A mock-up of the preliminary mechanical design was delivered on schedule in January 1978. The safety program was also delivered on schedule and approved. The final draft of the Engineering Test Plan was approved in April 1978.

The Environmental Qualification Tests were completed on June 22, 1978 in accordance with the Engineering Test Plan. These tests were performed in accordance with Qualification Test Procedure (Engineering Test Specification 976962). The final bench Acceptance Tests for the six units were completed on July 24, 1978. The six units were shipped on July 25, 1978.

III. GENERAL DESIGN OBJECTIVES

The overall design of the Vehicular Applique unit is based on the requirements of Specification No. EL-CP0193-0001A and modifications. The unit is designed to meet all of the electrical and mechanical test requirements as specified in the Qualification Test Procedure (Test Specification 976962) which was approved in April 1978.

The electrical power control interface with AM-1780/VRC Amplifier is designed similar to the interface provided with the AN/VRC-12 family of radio sets. The same degree of remote or local power control is provided by the Vehicular Applique Unit.

The mechanical design of the Vehicular Applique unit is based on the AM-1780/VRC Amplifier to provide the same degree of ruggedness, simplicity of operation, and commonality of cable connectors to minimize non-standard hardware.

IV. ELECTRICAL DESIGN ANALYSIS

1.1 POWER CONTROL

The power control circuits of the Vehicular Applique are similar to that provided by the AN/VRC-12 family of radio sets. However, some of the functions were accomplished in a different manner in order to simplify the design.

With the AN/VRC-12, the power control link in the mount is used to select local or remote power control. This function is provided in the Vehicular Applique with one section of the Installation Switch (S101-A). The system fuse (100 amp in the VRC-12 mount) is located on the side of the Vehicular Applique. The rating of the fuse is reduced to 10 amp for this requirement which is high enough to prevent melting on transient over-voltage currents. This fuse is required to protect the vehicular electrical system. A spare fuse holder is also provided for convenience.

Analysis of the AN/VRC-12 and Vehicular Applique power control circuits shows nearly identical circuit configurations. In both cases the +25 VOC COM line from J501-D (Radio "A" Connector) on the AM-1780/VRC is used to control +25 VDC power to the R/T (Receiver/Transmitter)power control relay (K121 in the Vehicular Applique). See Figure D-1 in Appendix D. The main power switch on the AM-1780/VRC provides power to J501-D in the NORM position only. When this switch is at the INT ONLY or OFF positions power is removed from J501-D. J501-D is connected to J101-D on the Vehicular Applique with cable assembly CX-4723/VRC. With the Vehicular Applique Installation Switch in the REMOTE position, power is routed from J101-D thru S101-A, CB102 auxiliary contacts, J107/P121, and CR122 to K121. The low side

of K121 is routed thru P121/J107 and the auxiliary contacts of CB101 (R/T Power) to ground to complete the circuit.

When K121 is energized, power for the AM-1780/VRC, with its MAIN POWER Switch in the NORM position is routed from J103-B thru F101, J107/P121, K121 contacts, P121/J107, S101-D (Remote) to J101-C and J501-C of the AM-1780/VRC via CX-4723/VRC cable. When the AM-1780/VRC MAIN POWER Switch is at the INT ONLY position, power is routed from J103-B thru F101 directly to J101-B and J501-B of the AM-1780/VRC.

Therefore, when the Vehicular Applique INSTALLATION switch is at the REMOTE position and the AM-1780/VRC MAIN POWER switch is at the NORM position, power to both units can be controlled by either unit. Setting the R/T power switch or MAIN POWER switch of the Vehicular Applique to the OFF position removes power to the AM-1780. Power to the AM-1780 can then be restored by setting the MAIN POWER switch to the INT ONLY position. Likewise, setting the AM-1780/VRC MAIN POWER switch to the INT ONLY position removes power to the R/T circuits but not the speaker amplifier circuits of Vehicular Applique. Setting the AM-1780/VRC MAIN POWER switch to the OFF position removes power completely to both units.

The circuit breaker portion of CB101 (R/T Power) controls power to the +15 VDC Regulator, U122, and the AN/PRC-68 Radio Set. The auxiliary contacts of CB101 are used to provide control of power to the power control relay, K121.

The circuit breaker portion of CB102 (MAIN POWER) controls power to all functions of the Vehicular Applique including the AN/PRC-68 R/T unit. The auxiliary contacts of CB102 are used to control power to K121 and also to provide interruption of power to

K121 in the case of over-voltage which would trip the circuit breaker portion of CB102; an over voltage condition would then only occur across K121 coil for the short time interval required for CB102 to trip off, instead of a continuous overvoltage condition which would exist if the auxiliary contacts were not used. K121 is capable of handling an overvoltage condition for a short period of time which would prevent excessive power consumption and overheating. K121 also has separate reverse polarity protection provided by CR122 which protects the transient suppression diode, CR123, from burnout. The auxiliary contacts of both CB101 and CB102 are rated for 0.5 ADC at 28VDC or 0.1 ADC inductive load. The actuating current for K121 is approximately .06 ADC at 28 VDC.

When the Vehicular Applique INSTALLATION switch is at REMOTE and the AM-1780 MAIN POWER switch is at NORM, an over-current trip by either CB101 or CB102 will be indicated by the panel light on both the Vehicular Applique and the AM-1780, signifying loss of power to both units. If the AM-1780 circuit breaker trips off, the power to K122 is interrupted, which removes power to all circuits except the +15 VDC regulator and R/T unit. The loss of power will be indicated by the panel lights on both the Vehicular Applique and AM-1780/VRC. When the AM-1780 MAIN POWER switch is at INT ONLY, CB101 and CB102 have no control of the power distribution to the AM-1780/VRC. However, the AM-1780 still controls power to the Vehicular Applique thru J102 (J506)-C and K122. An AM-1780 circuit breaker trip will still be indicated by both panel lights, but an over-current trip by CB102 (MAIN POWER) will be indicated only by the panel light on the

Vehicular Applique. CB101 (R/T Power) is inactive (no R/T Power) when the AM-1780/VRC MAIN POWER switch is in the INT ONLY and OFF positions.

Both circuits breakers used in the Vehicular Applique are military qualified to MIL-C-39019B. Type A time delay was selected to provide relatively slow tripping time at 125% of rated current and fast tripping time at greater than 200% of rated current. The type A time delay prevents nuisance tripping on turn-on current surges and short duration voltage transients. The auxiliary contacts are ganged with the circuit breaker mechanism and provide convenient remote control switches. The auxiliary contacts are rated for 0.5 ADC at 28 VDC. The rating for CB101 (R/T Power) was determined by calculating the maximum current drain of the AN/PRC-68 Radio Set with the KYV-2 Secure Voice Module plus allowance for tolerances. With tolerance this maximum drain is approximately .45 ADC in the transmit mode. The 0.5 ADC circuit breaker will trip at 0.6 ADC within 7 seconds which provides adequate protection for both the Radio Set and Vehicular Applique circuits. Selection of the 1.0 ADC rating for CB102 (MAIN POWER) was based on the maximum current drain for all Vehicular Applique circuits plus the R/T unit. This current drain was calculated to be approximately 0.75 ADC and is based on the R/T unit in transmit mode, muted speaker output, and fully loaded headphone (microphone sidetone) output. The maximum current drain with the R/T unit in receive mode, 1.5 watt speaker output, and fully loaded headphone output is approximately 0.55 ADC. Both circuit breakers also function as power switches.

CB102 (MAIN POWER), in conjunction with CR121 (1N2825B), provide power line transient protection, overvoltage protection, and reverse polarity protection for the Vehicular Applique circuits. The design of this circuit is similar to that used in the AM1780/VRC. Electrically the zener diodes are the same; the TO-3 case was selected for low profile mounting and the two pin cathode arrangement which, if the zener diode is removed, disconnects power to the Vehicular Applique and R/T unit, thus preventing operation without the protection diode. However this protection feature is based on the assumption that the two connecting wires are not intentionally soldered together. The series resistance of CB102 is 1.2 ohms which is approximately equal to the total series resistance of R504 and CB501 in the AM-1780/VRC. Performance of the two circuits will therefore be nearly identical. A series resistor was not considered necessary for the Vehicular Applique because of the higher resistance of CB102 and a design goal to minimize input power line voltage drop thus maintaining the regulated output voltages for a power line input voltage as low as 20 VDC. The Vehicular Applique Acceptance Test Procedure verifies the proper operation of the input protection circuit for both +45 VDC (overvoltage) and -30 VDC (reverse voltage) input power line conditions. CR121 (1N2825B) is mechanically mounted to the A120 assembly board with heat conductive compound. Heat is conducted away from CR121 into the .090 thick aluminum A120 board and to the four housing mounting posts. The thermal resistance of the heat sink is less than $5^{o}C$ per watt which is adequate to maintain CR121 case and junction temperature within dissipation limits for

ambient temperatures up to 90°C.

The relays which were selected for use in the Vehicular Applique are both qualified to MIL-R-39016B for high level load ratings of 2 ADC at 28 VDC. The units that were purchased have a failure rate level of 3.0% per 10,000 operations (Level L). K121 is a 4PDT relay without protective diodes and is military type M39016/39-001L. K122 is a 2PDT relay with internal suppression and polarity diodes and is type M39016/38-026L. JAN 1N647 diodes were used in the design to provide suppression and polarity diodes for K121. K121 is not available with internal diodes at the present time. Both relays are mechanically mounted with case grounded to the A120 (Power Control Assembly) board. The mounting ear configuration on both relays was selected to provide the highest available shock rating which is 100G for K122 and 75G for K121. K121 is required to provide the necessary remote power control between units. K122 provides a means to disable power to the Vehicular Applique when the AM-1780 MAIN POWER switch is set to the OFF position, thus removing power to the complete system with one control. K122 is required to perform this function because the AM-1780/VRC is not designed to provide sufficient current to drive the +18 VDC Regulator and Speaker Amplifier circuits directly. The AM-1780/VRC internal +25 VDC power line from J102-C is thus used only for control of K122, which draws approximately the same amount of current (.02 ADC) as the A80 Microphone Amplifier used in the control boxes. J102 is normally connected to a control box connector (J505, J506, or J507) on the AM-1780/VRC with cable assembly CX-4723/VRC. Overvoltage protection

for K122 is provided by the AM-1780/VRC when the Vehicular Applique is set for REMOTE installation. For LOCAL installation CB102 and CR121 provide protection for K122.

The panel indicator light that was selected is the same type used on the AM-1780/VRC. The holder is a type LH89/1. The lamp is a type 25237-327 which is a T 1-3/4 rated for 28 VDC. The lens is a type LC36YD2, which is adjustable and can be closed off for blackout conditions. The panel light is intended to provide an indication of power to the unit and if possible illumination of the control panel. This type of lamp is not designed for illumination purposes, however a full, non-adjustable lense may be available for the holder if the blackout capability is not an absolute requirement. In most cases the Vehicular Applique will be mounted inside the cab of the vehicle and the adjustable lense may not be required. However, the amber color was selected for the lense to provide the maximum amount of illumination with an adjustable lense.

1.2 VOLTAGE REGULATORS

The voltage regulators that were selected are integrated circuits mounted in a standard TO-3 case. The regulators are Signetics type 78HV18DA (+18 VDC) and 78HV15DA (+15 VDC). Both types are positive voltage regulators capable of 1.0 ADC continuous load current when adequately heatsunk. The HV signifies a high input voltage breakdown rating of 60 VDC minimum. This BIV rating was considered necessary to provide input protection margin for the regulators when large voltage transients are present on the vehicular power line; during the time of large voltage transients the voltage drop across CR121 may exceed +40 VDC. The HV type regulators thus provide a +20 VDC margin over the low voltage types rated for a BIV of +40 VDC. Other reasons for selection are excellent temperature characteristics, designed in fold-back current limiting and safe-area thermal compensation which provide output short-circuit protection and prevent thermal run-away and self-destruction, 5% tolerance on output voltage over the temperature range, and hermetically sealed TO-3 power package. These regulators are not military qualified at the present time but have the mechanical and electrical quality required of a military standard part. All of the purchased regulators were tested at the component level before installation to verify the proper performance characteristics and protective functions. No failures were encountered during these tests.

The +15 VDC Regulator is used to provide power only for the R/T unit, which consists of the AN/PRC-68 Radio Set with or without the KYV-2 Secure Voice Module. Power control and overcurrent protection for both the +15 VDC Regulator and R/T unit are provided by CB101. CB101 is used on the +25 VDC input line rather than the +15 VDC R/T power

line because of the 2 VDC drop across the 4 ohm resistance of CB101 at a load current of .45 ADC. The R/T unit thus is provided with a well regulated input, independent of load current, while the regulator is still capable of maintaining output regulation with an input voltage of 20 VDC including the 2 VDC drop across CB101 and a 1 VDC drop across CB102. Both regulators are capable of maintaining regulation at rated current with Vin to V out differential as low as 1.7 VDC. The 1 VDC drop across CB102 is due to the combined transmit-mode maximum load current of the R/T unit (.45 ADC) and the Vehicular Applique circuits (.30 ADC). At an input voltage of 20 VDC the regulation of the +18 VDC regulator would be marginal under these worst case maximum load current. A slight drop in the output level of the +18 VDC regulator will not degrade the speaker and headphone amplifier outputs at rated levels. The amplifier circuits will still provide undistorted outputs under full load conditions with regulator output as low as +16 VDC. The +18 VDC regulator was selected to provide margin for higher reserve peak power capability in both circuits. Therefore, in the case of the +18 VDC regulator operating with an input voltage of 20 VDC, the main concern would be reduced line regulation which would allow power line ripple and transients to pass thru the regulator. However, in this case the amplifier circuits are sufficiently decoupled to prevent distortion and interference at their outputs. The response time of the regulators is fast enough that input voltage transients would be clamped at the rated regulator output voltage and not passed directly thru the regulator to the amplifier circuits. Regulator power dissipation would not be a problem because of the low Vin to Vout differential. When operating the regulators with input voltages of 30 VDC the major concern

is regulator power dissipation. The worst case is for the +15 VDC regulator since the differential voltage is highest (Vin - Vreg = Vdiff) at 15 VDC and the load current is highest at .45 ADC. This results in a regulator power dissipation of Vdiff x Iload of 6.75 watts. The maximum allowable dissipation for the regulator package without heatsink is given by

$$P_D\ (Max) = \frac{T_J\ (Max) - T_A}{\theta_{JA}}$$

where, Maximum junction temperature, T_J (Max) = 150^oC

Ambient temperature, T_A = 75^oC Max

Thermal resistance, junction to ambient, θ_{JA} = $35^oC/W$

For $T_A = 25^oC$, P_D (Max) is 3.57 watts and for $T_A = 75^oC$, P_D (Max) is only 2.14 watts. A heatsink is therefore required to enable the regulator to dissipate 6.75 watts. The required θ_{JA} with heatsink is given by

$$\theta_{JA}\ (Req) = \frac{T_J\ (Max) - T_A\ (Max)}{P_D\ (Max)}$$

then $$\theta_{JA}\ (Req) = \frac{150^oC - 75^oC}{6.75\ W} = 11.1^oC/W$$

The required thermal resistance for the heatsink is then given by

$$\theta_{HS} = \theta_{JA}\ (Req) - \theta_{JC}$$

where θ_{HS} = Thermal Resistance, Heatsink $^oC/W$

θ_{JA} = Required Junction to Ambient Thermal Resistance $^oC/W$

θ_{JC} = Package Junction to case Thermal Resistance $^oC/W$

θ_{JC} for the regulator package is given in the device specifications as $4^{o}C/W$. Therefore, the minimum required thermal resistance for the heat sink is calculated as:

$$\theta_{HS}\text{ (min)} = \theta_{JA}\text{ (Max)} - \theta_{JC}$$

$$= 11.1\ ^{o}C/W - 4^{o}C/W$$

$$\theta_{HS}\text{ (min)} = 7.1\ ^{o}C/W$$

The regulator is directly mounted with heatsink compound to the Power Control Board, A120, which is approximately 4 inches by 3.5 inches of 3/32 inch thick aluminum. The thermal resistance of the board is obtained from charts based on the following data:

1. Vertical or horizontal mounting
2. Material and thickness
3. Surface area

The mounting could be either way depending on orientation of the Vehicular Applique. For the given surface area and thickness, θ_{HS} for vertical mounting is $4.3^{o}C/W$ and for horizontal mounting is $4.8^{o}C/W$. For the worst case with θ_{HS} of $4.8\ ^{o}C/W$ the regulator-heatsink combination would be capable of dissipating 6.75w at an ambient temperature of $91^{o}C$ without exceeding the maximum junction temperature. As additional heatsink capability, the A120 board is directly mounted to four 3/8 inch diameter housing bosses, which by estimate would lower the thermal resistance of the heatsink by an additional $2^{o}C/W$. The +15 VDC regulator is required to dissipate maximum power when the R/T unit is in the transmit mode. During this mode the +18 VDC regulator dissipation requirement is minimized because of muted

speaker output of approximately 100 mW and sidetone output from the headphone amplifier of approximately 0.7 watt, assuming the headphone system is fully loaded to an impedance of 150 ohms for worst case analysis. The current drain thru the +18 VDC regulator for this case is approximately .15 ADC. The regulator dissipation for Vin of 30 VDC would then be 1.8 watts. The +18 VDC regulator is mounted to the A120 plate in the same manner as +15 VDC regulator. A mounting boss is adjacent to each regulator which, in addition to the plate, provides more than adequate heatsinking capability for both regulators.

The worst case dissipation for the +18 VDC regulator occurs when the R/T unit is in receive mode with a fully loaded headphone output and speaker output at full rated level. The +18 VDC current drain under these conditions is approximately .36 ADC. For an input voltage of 30 VDC the maximum regulator dissipation is then 4.32 watts. By the same analysis used for the +15 VDC regulator it is evident that the heatsink is properly designed. The +15 VDC regulator dissipation is approximately 1.05 watts when the R/T unit is in receive mode with full audio output. In standby mode with squelch on, the +15V regulator dissipation is only .5 watt. The operating junction temperature range for both regulators is $-55^{\circ}C$ to $+150^{\circ}C$. The line regulation for the HV series of regulators is typically less than 0.1% for an input voltage change from Vreg +2 VDC to Vreg +15 VDC. The maximum specified line regulation is less than 1.0%. The load regulation is typically less than 0.1% for a load current range of .005 ADC to 1.50 ADC. The maximum specified load regulation is less than 1.0%.

Diodes CR124 and CR125 (1N647) provide input short circuit protection for the regulators. The diodes effectively discharge large

bypass capacitors while clamping the regulator output voltage to prevent reverse voltage breakdown.

1.3 AUDIO AND KEYLINE CIRCUITS

The audio circuits provide three major functions:

1. Speaker Amplifier
2. Headphone Amplifier
3. Microphone Sidetone Amplifier

In addition to these functions two switching circuits, controlled by the radio and intercom keylines, are used to provide speaker output muting and gating of the sidetone amplifier output into the headphone amplifier input.

A high degree of parts commonality is maintained in the design of the audio and keyline circuits. The same type of integrated circuit is used to provide all amplifier functions. The vendor part number for this device is the National LM180. The actual devices that are installed on the A150 amplifier boards are burned-in and screened to the 900 level of MIL-STD-883. Magnavox Drawing No. 619905 defines the burn-in and screening requirements. The Magnavox Part No. is 619905-901. A copy of this drawing was submitted with the final report. The 619905-901 integrated circuit amplifier is currently used in the ARC-164 UHF Radio Set and has demonstrated a high degree of reliability on that program. The 619905-901 integrated circuit is the only non-standard part used in the design of the A150 Audio Assembly.

1.3.1 SPEAKER AMPLIFIER

The design goal for the speaker amplifier is to provide a minimum of 1.0 watt average power output into an 8 ohm load (M12606-02 Speaker) with an input level of 10.0 VRMS to the speaker amplifier circuit. Also required is a speaker muting function which reduces the

output level of the speaker automatically, when a microphone on either the radio or intercom circuits is keyed, to prevent acoustical feedback or howl. The muting level used in this design is 10dB $\pm$3dB which is based on the equipment specification for the RT-524 Radio Set. The muted speaker output power level is typically 100 mW. The muting circuit consists of a gated or switched Tee attenuator with the shunt arm controlled by a P-channel JFET (2N2609). See Figure D-2 in Appendix D. If the radio or intercom circuits are not keyed then the shunt arm consisting of R154 and Q151 is an open circuit which provides a normal audio level of 69 mV at the input of the speaker amplifier, U151. R152 is normally adjusted to provide 1.5 watts speaker output power with an input to P151-1 of 10.0 VRMS. When the radio or intercom circuits are keyed Q151 reverts to a low resistance of approximately 300 ohms. The shunt arm of the attenuator then has a resistance of 2.3K ohm which attenuates the signal at the input of U151 to 19mV, which is an 11 dB reduction in signal level.

The switch states of Q151 are controlled by the DC voltage across R156 (V_{GS}). When the keylines are open, V_{GS} is set to approximately +8.0 VDC by the voltage divider consisting of R157, CR151, and R156. Since the maximum specified V_{GS} OFF for the 2N2609 is +4.0 VDC, Q151 will be in the OFF state and the drain to source resistance will be several megohms. When the radio keyline is grounded, the voltage at the junction of R157 and CR151 will be clamped to 0.6 VDC by CR153. In this condition, the impedance of CR151 is very high which effectively blocks current flow to R156. V_{GS} then drops to ØVDC which forces

Q151 into the low resistance ON state. The intercom keyline controls the circuit in the same manner. Diodes CR152 and CR153 also provide DC isolation from keyline power sources, prevent keyline interaction, and in conjunction with C151 provide relay-voltage transient protection for the muting circuit. The muting level or attenuation of the Tee network can be easily adjusted by substituting a different value resistor for R154.

Several types of integrated circuit amplifiers were evaluated for the speaker amplifier design. Among these were the Fairchild TBA800 and TBA810 and the National LM180 and LM184. The Fairchild circuits performed well over the temperature range but required an excessive amount of external components. In addition the Fairchild devices are not specified for the military temperature range. The National LM180 and LM184 are basically the same device except that the LM184 has a higher supply voltage rating and higher power output capability. However, when operated with a supply voltage of +18 VDC their performance is identical. Since none of the devices which were evaluated had a supply voltage rating high enough to be operated directly from the vehicular +28 VDC power source, some type of supply voltage reduction circuit was required. A series zener diode was considered unacceptable since it would limit the output power of the amplifier with a vehicular supply input of 20 VDC, and large tantulum bypass capacitors would be required for line filtering and transient suppression. The series regulator approach which is used has none of these drawbacks. For this application the regulator voltage selection was either +15 VDC or +18 VDC. The +18 VDC regulator was selected to provide higher amplifier output voltage swing and peak power handling

capability. With the +18 VDC regulator the speaker amplifier is capable of 3.0 watts RMS power output before peak clipping occurs. The peak clipping level also remains constant over the voltage range of the vehicular electrical system.

The LM180 amplifier has many excellent features which make it a very sturdy and reliable device. Among these features are:

--Output short circuit protection with internal thermal limiting

--Fixed gain of 34dB

--High peak current capability

--Input referenced to ground

--High input impedance

--Low distortion

--Quiescent output voltage at one-half the supply voltage

--Low quiescent power drain

--Standard dual-in-line package

The LM180 devices used in the assembly of the Vehicular Applique sets are burned-in and screened to the MIL-STD-883, 900 level requirements stated in Magnavox Part Drawing 619905. The Magnavox part number for this device is 619905-901.

The heatsink for the speaker amplifier is the 2 mil thick copper-clad ground plane surface area of the A150 audio assembly printed circuit board. This ground plane surface area is approximately 14.2 square inches excluding the open areas. The thermal resistance of the A150 board alone is approximately $20^{o}C/W$. The combined thermal resistance of the A150 board mounted to the five housing bosses is approximately 15^{o} C/W based on laboratory measurements

of the lead temperature of the amplifier when operating with 2 watts power output in an ambient temperature of 75°C. The device junction to ambient thermal resistance when mounted on this heat sink is then

$$\theta_{JA} = \theta_{JL} + \theta_{HS}$$

Where θ_{JL} (junction to lead-frame thermal resistance) = 12°C/W

θ_{HS} (heatsink thermal resistance) = 15°C/W

Therefore θ_{JA} = 27°C/W

And $$P_D \text{ (max)} = \frac{T_J \text{ (max)} - T_A \text{)max)}}{\theta_{JA}}$$

Where T_J (max) = 150°C (device specification)

T_A (max) = 75°C

Therefore P_D (max) = 2.78 watts

Since the maximum power output of the device is limited to 3.0 watts by the +18 VDC supply voltage, and the efficiency at full output power is 60%, the device dissipation is limited to 2.0 watts which is well within the maximum power dissipation limit. The efficiency of the amplifier varies from 36% at 1 watt output to 50% at 2 watts output and 60% at 3 watts output. Over this range of output power the device dissipation is nearly constant at 2.0 watts. The internal thermal limiting circuit of the device prevents device destruction if under abnormal circumstances the junction temperature approaches 150°C. The thermal limiting circuit senses the junction temperature and maintains it below 150°C by reducing the output power and power dissipation of the device.

Operating the Vehicular Applique at an ambient temperature greater than

+75°C would then only reduce the maximum output power capability of the amplifier with no danger of damage to the integrated circuit.

As can be seen from the schematic, a minimum of external parts are required with the LM180. C153 provides supply line decoupling for the preamplifier portion of the integrated circuit. C155 provides DC blocking and audio coupling to the speaker. R159 and C154 provide high frequency compensation for gain stability with low impedance loads.

1.3.2 HEADPHONE AMPLIFIER

The LM180 is also used for the headphone amplifier. This circuit amplifies the audio output of AN/PRC-68 receiver and the microphone audio from the Sidetone Amplifier to the proper level for the headphone and monitor lines. The gain of this circuit is set by R165 to provide 10 Vrms output level to the headphone circuits with a receive audio input to J104-B of 1.5 Vrms and a sidetone microphone level of 5.0 millivolts at J104-D. The 10 Vrms level provides a headphone output power of 167 milliwatts into a 600 ohm load. The RT-524 specification for headphone output is 100 milliwatts minimum into a 600 ohm load. The output of the Headphone Amplifier circuit drives the intercom headphone, GDU headphone, and monitor lines. The LOCAL R/T headphone is taken from the tap of R101 (SPKR VOL) to provide volume control of this function; the reason will be explained later in the text.

The transformer (T151) output circuit of the headphone amplifier circuit is very similar to that used in the RT-524 unit. The output impedance is approximately 50 ohms with an output power capability greater than 1.0 watts when driving a 150 ohm load (equivalent to four 600 ohm headphone loads). The 50 ohm output impedance includes the 10 ohm resistor (R174). R174 provides output short-circuit protection for T151 and also prevents complete loss of audio to the monitor line if the headphone circuit (J101-H) becomes shorted to ground. R161, in conjunction with an internal shunt 150 ohm resistor in the AM-1780 amplifier, attenuates the headphone output level to a nominal monitor level at J101-K of 250 millivolts. The RT-524 specification for the monitor level is 160 millivolts minimum and 310 millivolts maximum with an output impedance greater than 1800 ohms. The Vehicular Applique monitor output impedance is approximately 6000 ohms. All of the headphone outputs are taken from the 150 ohm tap of T151. The impedance seen by

the amplifier circuit (U152) will vary from 15 ohms with a 150 ohm output load to 60 ohms with a 600 ohm output load. The response of the circuit is essentially flat from 300 Hz to 3000 Hz for any output load from 150 ohm to no-load. A flat response was considered desirable for this circuit since the audio output of the AN/PRC-68 receiver rolls off at 12dB/octave and the AM-1780 interphone amplifier rolls off at least 12dB/octave; the goal was to prevent a bassy sound or degradation of high frequency response. In conjunction with flat speaker amplifier and headphone amplifier response, the monitor-to-AM-1780 interphone amplifier-to speaker amplifier audio loop provides a very clear and crisp output from the speaker.

The volume control on the AN/PRC-68 R/T unit is normally set to the maximum output level position to provide the proper fixed headphone output levels. It was considered desirable from a human engineering standpoint to set this control at a fixed (stopped) position and not attempt to use it as the volume control for the LOCAL R/T headphone output. As a result of this conclusion, the LOCAL R/T headphone output was taken from the tap of R101 (SPKR VOL) which allows R101 to be used as a level control for this output. The results are fairly good especially when the SPKR VOL control is set for less than 100 mW speaker output. In this case the speaker acoustical level is not objectionable and the LOCAL R/T headphone level is adequate. If the SPKR VOL control is set to the SPKR OFF position, the LOCAL R/T headphone output is not disabled and is still adequate except for very high ambient noise levels. An additional possible advantage is that the LOCAL R/T headphone output also monitors all traffic from the AM-1780 interphone amplifier. As an alternate approach which was

discarded, the LOCAL R/T headphone output was tied directly to the headphone amplifier output, but this fixed high level output was considered to be very annoying and uncomfortable with the only provision for level control being the R/T unit volume control. The GDU headphone output is fixed level but is used only for data mode and not voice. The GDU output level can be tailored by substitution of a different value for R160.

The headphone amplifier integrated circuit, U152, is mounted to the A150 board in the same manner as the speaker amplifier integrated circuit, U151. The maximum dissipation requirement for the headphone amplifier is approximately 1.0 watt, assuming Pout is 1.0 watt into a 150 ohm load and an efficiency of 50%. Through previous analysis for the speaker amplifier, it can be seen that the heatsink capability of the mounted A150 board is sufficient for both amplifiers under worst case conditions.

1.3.3 SIDETONE AMPLIFIER

The sidetone amplifier was included in the Vehicular Applique design for human engineering reasons. The AN/PRC-68 Radio Set does not provides sidetone output during the transmit mode and during initial bench tests with the AM-1780 amplifier this lack of sidetone was considered to be unacceptable for operator confidence, especially for operators accustomed to hearing sidetone. Although the sidetone output provided in the Vehicular Applique does not provide a true confidence check on the proper operation of the transmitter, lack of sidetone output will indicate open keylines, absence of microphone audio signal, and R/T unit over-current fault on the +15 VDC supply line or an R/T unit which is not energized. The R/T POWER circuit breaker (ON-OFF switch) controls power to the Sidetone and Headphone amplifiers in addition to the R/T unit. Sidetone audio gating into the Headphone amplifier is controlled by both the AM-1780 (J101-S) and LOCAL R/T (J105-C) radio keylines. The GDU keyline does not activate the sidetone amplifier in order to keep data signals out of the intercom headphone system. The sidetone output level into the headphones is typically 12dB below normal receive headphone level, assuming the average voice level from the microphone is approximately 1 millivolt. For test purposes the sidetone output (Headphone, J101-H) is specified at a nominal 10.0 Vrms for a microphone input of 5.0 millivolts to the input of the sidetone amplifier (U153-6). The sidetone gating circuit (Q152) also prevents potential stray pickup on the microphone lines from entering the headphone amplifier during the R/T receive mode. The operation of the gating circuit is identical to the speaker mute circuit except for Q152, which performs as a series

switch instead of a shunt switch. The same LM180 device is used for the sidetone amplifier function to maintain parts commonality. Sidetone amplifier power dissipation is insignificant. R172 and C164 provide additional power line decoupling. C166 provides RF bypassing of the microphone input lines to prevent amplifier blocking.

1.3.4 MICROPHONE CIRCUITS

The microphone input to J104-D and the sidetone amplifier (J108/P151-13) is tied directly to the GDU (J106-D) and LOCAL R/T (J105-D) microphone lines. The microphone output from the AM-1780 amplifier (J501/J101-U) is attentuated 30 dB by the network consisting of R164, R173, and the 150 ohm resistance of the R/T microphone input (J104-D). This 30 dB attenuator offsets the 30 dB gain of the A80 microphone amplifier used in the intercom system control boxes. For normal voice levels the microphone input level to the R/T unit is approximately 1.0 millivolt which will FM modulate the RF carrier to ±8 kHz frequency deviation. The AN/PRC-68 Radio Set design provides deviation limiting at ±15 kHz and filtering at 12dB/octave above 3 kHz modulating frequency to prevent over-modulation and spectrum spreading.

1.3.5 R/T KEYLINE CIRCUITS

Both the AM-1780 amplifier (J501/J101-S) and LOCAL R/T (J105-C) keylines will activate the sidetone amplifier when grounded; the low side of the R/T keying relay is pulled to ground thru CR155 in this case. CR155 prevents the GDU keyline from activating the sidetone amplifier and also provides a high impedance to ground on the speaker mute keyline when the R/T unit is de-energized and only intercom traffic is monitored. Without CR155, the low impedance seen thru the de-energized R/T relay to the supply line would result in false keying of the mute circuit. The GDU keyline (J106-C) is tied directly to the R/T unit keyline (J104-C).

1.3.6 AUDIO CONTROL CIRCUITS

The speaker volume control is wired in series in the same manner as used in the intercom control boxes. The minimum volume level is at least 35 dB below full volume but cannot be set to zero unless the speaker volume control is set to the OFF position. LOCAL R/T headphone output is still available at this setting but at minimum volume. The volume control is manufactured to military standards of MIL-R-94 and is designed to provide a reverse log "F" taper, which is standard for this application.

Section S101-B of the Vehicular Applique INSTALLATION switch is used to select the speaker amplifier input signal from either the AM1780 amplifier in the REMOTE position, or the Headphone amplifier in the LOCAL position. With REMOTE operation the speaker amplifier monitors "ALL" radio and intercom traffic which is tied into the AM-1780 amplifier. In the LOCAL position only radio "A" or AN/PRC-68 traffic is monitored by the speaker amplifier; however, "All" traffic including the AN/PRC-68 is still monitored at the control box outputs if the intercom system is connected to the Vehicular Applique. The J101/J501 Vehicular Applique to AM-1780 interface defines the Vehicular Applique R/T unit (AN/PRC-68) as system Radio "A".

1.4 AN/PRC-68/VEHICULAR APPLIQUE INTERFACE

Cable Assembly 467654-801 provides the electrical interface between the AN/PRC-68 Radio Set and the Vehicular Applique unit. This cable assembly consists of five unshielded AWG 22 wires and one shielded AWG 24 wire. The wire functions are as follows:

J1 or J104	Pin A/Ground-Black
	B/Receive Audio-Brown
	C/Keyline-Green
	D/Microphone-White/SHLD
	E/Power-Red
	F/Spare-Yellow

The pin F connection will eventually be used to provide a squelch disable function for the GDU interface. Both ends of the cable are terminated with standard 6-pin audio connectors. The wires are enclosed in a braided sheath which is rolled over and soldered to washers at each end to provide mechanical strength. The sheath is covered with .040 inch thick heavy-wall neoprene shrink tubing. The complete cable assembly is watertight. The sheath is mechanically captivated at both ends by the connector bushings. The cable is strong enough to be used as a handle but this practice is not recommended. A carrying handle is provided on the mounting plate of the Vehicular Applique.

1.5 ANTENNA INTERFACE

The design goal for the antenna interface between the bulkhead mounted AT-892 antenna and the AN/PRC-68 Radio Set is to provide an installation whereby the AN/PRC-68 Radio Set can be used for both portable and vehicular operation at the same frequency without removing the R/T cover and readjusting the antenna coupler tuning. This concept is adequate for field use if reduced communications range is acceptable. Since the radio set is designed to impedance match with the AT-892 antenna when hand-held, a significant mismatch is encountered when the AT-892 is installed on a ground plane and connected to the radio set with a length of cable. The portable mode antenna coupler setting is not optimum for this condition. The length of the interface cable is also a compromise between degree of mismatch and ease of installation. A very short cable of less than six inches length would reduce the mismatch and increase range but is not long enough to allow convenient mounting of the antenna base in the vehicle. Based on inputs from Fort Sill personnel, a minimum cable length of 18 inches is required for the installation of the antenna base and Vehicular Applique unit. Therefore, as a compromise to provide maximum range the minimum length of 18 inches was selected.

From an EMI standpoint it was considered desirable to use shielded coaxial cable for the interface to minimize radiation inside the cab of the vehicle. Type RG-62B/U cable was selected to provide the least amount of shunt capacitance and mismatch. A standard PL-259 is used on one end of the cable to interface with the antenna base assembly. The other end of the cable is terminated with a modified PL-259 plug which has a special shell and center plug adaptor to provide interface with

the antenna post on the AN/PRC-68 radio set. The special shell grounds the cable shield to the radio set by engaging threads at the bottom of the radio set antenna mount.

The radio set is bonded to the Vehicular Applique mounting plate with a 3-inch long by .25 inch wide braided strap. The strap is attached to the plate with an internal tooth lug and a 10-32 machine screw. The other end of the strap is terminated with a lug. A thumb screw is captivated to the lug with a toothed lockwasher. Installation of the radio set simply involves threading the thumb screw into a tapped hole on one of the protective bosses on the panel of the radio set.

An alternate method for bonding the radio set would be to attach a clamp to the shell of the power interface cable at the radio end, however this connection would not be as positive and reliable as the thumb screw. The clamp would also interfere with installation of the power interface cable to the radio set. The thumb screw approach also maintains the bond on the radio set if the radio set is used independent of the Vehicular Applique while still mounted in the harness and connected to the bulkhead antenna. In this case the power-audio interface cable would be disconnected and replaced by a handset or other audio accessory. This independent operating mode would be especially important in the event of a vehicular power system failure.

Laboratory measurements were made with a mock-up antenna installation to determine the relative field strength of the vehicular antenna system as compared to the hand-held AN/PRC-68 Radio Set with the AT-892 antenna. The observations were made at 2 MHz intervals across the 30 MHz to 80 MHz operating band of the radio set. A

spectrum analyzer and frequency counter were used to observe the frequency stability and spectral purity of the radiated signals. No frequency instability or excessive spurious content were observed at the test frequencies. However, the relative carrier strength of the vehicular antenna was consistently 6 to 8 dB below the hand-held carrier strength. This would indicate a decrease in range of approximately one octave compared to the hand-held radio. The range of the hand-held radio is approximately 2 miles.

The antenna base assembly consists of an insulator, PL-259 female mating connector, threaded insert for the antenna, and a sealing gasket. The insulator material is polycarbonate plastic to Federal Specification L-P-393A and is flameproof. The sealing gasket material is silicone rubber which is also flameproof. The threaded insert is machined from stainless steel and tapped at one end for the AT-892 antenna and the other end for a threaded solder terminal. The internal connection between the connector and insert is made with wire soldered at both ends. The antenna base assembly is mounted to the outside surface of the cab bulkhead with three bolts. The center portion of the assembly fits in a one inch clearance hole through the bulkhead.

1.6 EMI CONTROL

The purpose of the EMI control design is to minimize conducted RF interference between equipments which interface with the Vehicular Applique. The two most important interface areas which were considered are the 28 VDC power line and the AN/PRC-68 power-audio connector, J104. Pi network EMI suppression filters are used at these interface points to minimize both susceptability and emission.

The 28 VDC power line filter, FL121, is a military qualified type M15733/25-0006. The maximum ratings are 5 ADC and 150 VDC. The Pi network configuration was selected to provide bidirectional filtering. The insertion loss of this filter is greater than 50 dB at 1 MHz and approximately 80 dB from 10 MHz to 1 GHz. The filter is mechanically mounted and grounded to the A120 Power Control plate, which is grounded to the Vehicular Applique housing through four .375 inch diameter mounting bosses with self-locking captivated thumb screws. All ground path mating surfaces are aluminum.

J104 is a General Connector type GC283F, 6-pin filtered audio connector. All pins except A (ground) have an internal Pi network filter which is grounded to pin A and the connector shell. The shell is grounded directly to the Vehicular Applique housing when the connector is installed. The low-pass Pi network filters, as tested per MIL-STD-202, provide 30 dB attenuation at 10 MHz and up to 80 dB at 12 dB/octave slope above 10 MHz. This connector thus provides susceptability and emission control for both the Vehicular Applique and the AN/PRC-68 Radio Set.

V. MECHANICAL DESIGN ANALYSIS

The Vehicular Applique is designed to meet the requirements of MIL-STD-810C and MIL-S-901 in accordance with Specification EL-CP0193-0001A and modifications. The primary mechanical design goals are to provide:

1. A housing for the Vehicular Applique electrical circuits, controls, and connectors which can be easily removed for maintenance or repair.
2. A shock and vibration isolated mounting harness which securely retains the AN/PRC-68 Radio Set yet allows for quick installation and removal of the radio set.
3. A Vehicular Applique mounting plate to which the housing and radio harness are attached that allows the Vehicular Applique to be installed in the vehicle in the same manner as the AM-1780/VRC amplifier.
4. Commonality of connectors used on the AM-1780/VRC and Vehicular Applique so that existing CX-4720/VRC and CX-4723/VRC cables can be used for installation.
5. A bulkhead mounted antenna base insulator which accommodates the AT-892 tape antenna and the antenna interface cable from the AN/PRC-68 Radio Set.

These primary design goals have been achieved. The specified requirements of MIL-STD-810C and MIL-S-901 have been met and is demonstrated by the successful completion of the environmental tests. A few minor deficiencies were noted and are covered in the final test report.

1.1 Housing

The mechanical design for the Vehicular Applique housing and mounting plate is based on the AM-1780/VRC amplifier. The AM-1780/VRC amplifier was used as a guide in order to provide the same degree of ruggedness and commonality of connectors and mounting.

The Vehicular Applique housing is attached to the mounting plate with eight 10-32 captive seal screws. Seal screws are not required on the four corner mounting holes but are used for parts commonality. Seal screws are required for the other mounting holes since these bosses are inside the housing sealing "O" ring gasket. The housing bosses contain self-locking steel threaded inserts which prevent the mounting screws from loosening during vibration and shock. Four guide pins are used as locators and stops to properly position and hold the housing during installation to the mounting plate. The mating surfaces of the housing and mounting plate are environmental sealed by a grooved "O" ring gasket which is positioned around the perimeter of the housing. The gasket is bonded into the groove on the mounting plate with RTV sealant-adhesive.

The housing provides the mounting surfaces for the controls and interface connectors, and the internal mounting bosses for the A120 Power Control Assembly board and the A150 Audio Amplifier Assembly board. Additional bosses are provided for electrical ground connections. All hardware which is mounted through external surfaces of the housing are environmentally sealed to the housing mating surfaces with "O" ring gaskets. A thin film of silicone grease is applied to the "O" rings before installation to ensure a positive seal.

For the six prototype units the housing and mounting plate were tape machined from aluminum alloy material 2024-T6 and 6061-T6 respectively. Machined parts were purchased to minimize tooling charges and obtain shorter lead time. For production quantities the housing and mounting plate would be cast with aluminum alloy 356-T6. The high casting-tooling charges for six units was considered to be uneconomical since the mechanical design may be subject to change, depending on field results and the GDU interface modifications.

The mating connectors, J107 and J108, for the Power Control board (P121) and Audio Amplifier board (P151) respectively are rectangular, miniature, polarized shell types qualified to MIL-C-24308A. J107 and J108, which are provided with floating mounts to aid connector alignment, are attached directly to the housing bosses with 2-56 machine screws and spacers. The screws are locked in place with self-locking threaded inserts installed in the bosses. P121 and P151 are mechanically mounted to the boards with 4-40 machine screws and vibration proof hex nuts.

The A120 Power Control Board is fabricated from .090 inch thick aluminum sheet material to provide a rigid mounting surface for the components. This board is securely mounted at four corners to housing bosses with 6-32 self-locking captive thumb screws. Free-running threaded inserts are used in these mounting bosses to maintain smooth, non-binding thread engagement with repetitive removal and installation of the A120 board. All components on the A120 board are securely mounted with machine screws and vibration-proof nuts. Where electrical grounds are required the machine screws and nuts are locked with internal tooth lock washers and lugs.

The A150 Audio Amplifier printed circuit board is .090 inch thick

G-10 glass-epoxy laminate with double-sided 2 ounce copper-clad and plated through holes. The .090 inch board thickness provides a very rigid mounting surface for the components and minimizes flexing and the possibility of fractured solder joints during vibration and shock. The A150 board is attached to five housing bosses with 6-32 self-locking captive thumb screws. The extra center boss provides additional mechanical rigidity and a heat-flow path from the A150 ground-plane heatsink into the housing. The audio transformer is mounted with two 4-40 machine screws and lock-washers. The tantalum capacitors are securely retained by component clips which are riveted to the board.

The internal wiring harness ground connections are made to three housing bosses with 8-32 machine screws and internal tooth-locking lugs. The bosses are tapped without inserts to provide low resistance ground connections.

The M12606-02 speaker is housed in a separate cavity which is environmentally sealed from the inside of the housing. The speaker cavity design is based on the RT-524 and provides an air pressure relief slot in the bottom surface. The speaker electrical connections are made through two sealed feedthru terminals on the rear surface of the speaker cavity. When the speaker is installed, the cavity is sealed against rain and dust by the speaker gasket. The speaker is mounted to four cavity bosses with 10-24 captive machine screws. The M12606-02 speaker is fungus, gunblast, and immersion resistant.

The overall mechanical design of the housing has proven adequate as verified by the environmental qualification test results.

1.2 MOUNTING PLATE

The Vehicular Applique mounting plate provides a rigid mounting surface for the housing and the four shock mounts which support the radio set harness. As stated before the housing is attached and sealed to the mounting plate with eight 10-32 captive machine screws and an "O" ring sealing gasket. Each shock mount is attached to the plate with two 6-32 machine screws and self-locking, vibration-proof nuts. Six ears are provided on the mounting plate for attaching the Vehicular Applique unit to the vehicle mounting bosses. Six ears were considered necessary because of the greater length and weight of the combined AN/PRC-68 and Vehicular Applique versus the AM-1780/VRC amplifier. The extra ears minimize flexing at the center of the plate and distribute the total force load to six ears instead of four during vibration and shock. The Vehicular Applique is mounted to the vehicle bosses with six 5/16 - 18 bolts and lock washers. EMI bonding of the Vehicular Applique to the vehicle can be achieved by using internal tooth lock washers on at least two of the mounting ears. A carrying handle is provided on the Vehicular Applique unit by an oblong cutout area on the mounting plate midway between the shock mounts.

1.3 RADIO HARNESS

The purpose of the radio harness is to provide a shock and vibration isolated retaining mount for the AN/PRC-68 Radio Set when it is installed for operation with the Vehicular Applique unit. The harness is designed to accommodate four different lengths of the radio set depending on the following module combinations:

1. R/T module and short battery case for the mercury battery.
2. R/T module and long battery case for the lithium battery.
3. R/T module, SVM module, and short battery case.
4. R/T module, SVM module, and long battery case.

Combinations 1 and 2 are retained in the harness by two clamps. Three clamps are used to retain combinations 3 and 4. Each clamp consist of two sections. One section, on the left hand side of the radio set, is hinged to drop down and provide clearance for inserting the radio set into the harness. The other section is a pivoting arm which swings toward the Vehicular Applique housing to provide additional clearance. The two sections are securely fastened together with a thumb screw which is captivated to the pivot arm and screws into the hinged arm. No problems were encountered with the clamp thumb screws loosening up during vibration and 30G shock tests. However, the thumb screws did loosen approximately 1/8 turn after six hammer blows during the ballistic shock test. The thumb screws would have to loosen by two complete turns to become disengaged from the threads.

A bottom stop is provided on the harness for the four combinational lengths of the radio set. This stop consists of a keyed "L" bracket with a thumb screw retainer. The stop is keyed to a thru hole in the harness plate to prevent turning. The thumb screw is captivated to

the "L" bracket and engages threads in the harness plate. The complete stop bracket is captivated to the harness plate with a six inch long nylon tether cord to prevent loss. A minor failure was encountered with this thumb screw during the vibration test on the axis normal to the harness plate. The plate experienced resonance deflection at 38 Hz which disengaged the bottom stop from the harness plate. A fix was applied which consisted of coating the threads of the thumb screw with reusable "VIBRA-TITE" nylon based thread lock. One coating is sufficient for 5 or 10 reinstallations of the stop to the harness plate. No further problems were encountered. The coating was not required on the clamp thumb screws. The thumb screws will be redesigned for better vibration and shock immunity on future units. The "VIBRA-TITE" fix was considered adequate for the six development units. The harness plate will also be stiffened on future units to minimize the resonant flexing at the center.

The complete harness is fabricated from stainless steel to provide optimum structural strength and corrosion resistance on the unpainted surfaces. Silicone rubber pads are bonded to the inside surfaces of the harness to protect the finish on the radio set and minimize movement of the radio set inside the harness. A fixed stop, which butts against the panel of the radio set, is provided at the top of the harness. The top retaining arm is designed with a mechanical interlock which enables installation of the radio set only when the radio set POWER switch is at the OFF position. This interlock ensures that the radio set is powered by the Vehicular Applique and not the battery. However, no electrical damage can occur to either unit if the POWER switch is set to the ON postion when the radio set is

electrically connected to the Vehicular Applique.

The physical location of the vibration isolators on the harness plate is based on the average center of gravity of the four combinational lengths of the radio set when mounted on the plate. The calculations which establish the center of gravity for each case are given in Appendix B. Paragraph B-1 gives calculations for the individual components. Paragraph B-2 gives calculations for the combined module lengths. Paragraph B-3 gives calculations for the combined center of gravity for the four radio configurations and the harness. The four combined center of gravity values were physically plotted on the layout drawing of the R/T and harness assembly. The composite center of gravity of 4.82 inches was thus calculated as shown in paragraph B-4, and the vibration isolators were located symmetrical about this point. For stability, the isolators were separated with respect to each other and the center of gravity as far as possible.

An alternate scheme that was considered for retaining the radio set was to use Neilsen fasteners instead of the thumb screws. However, this approach was discarded since fixed arms instead of pivoting arms were required, which made installation of the radio set difficult. The top arm must pivot to provide the power switch interlock function.

An unfortunate aspect of the program is that the stop positions for the long battery box were located on the harness plate based on information supplied by the USMC. This information indicated that the lithium battery box would be one inch longer than the present mercury battery box and the design of the harness was based on that length.

Information obtained in June 1978, which is too late for a redesign of the six units, states that the new lithium battery box will be approximately 1.5 inches longer than the mercury battery box. The harness will then have to be increased in length at the longest stop position for future units. However, the present design on the six units will accomodate the radio and short battery box with or without the SVM module.

VI. PRELIMINARY TEST RESULTS

Development units SN1 and SN2 successfully completed pre-acceptance and environmental qualification tests. These tests were performed in accordance with the Final Draft Test Plan and Qualification Test Procedure 976962.

A few changes were made in the test procedure before starting the tests. One of these changes was the decision to use the M12606-02 speaker as the test load for the speaker amplifier instead of an 8 ohm resistor. The reason for this change was to ensure that the complete system would be monitored during the environmental tests. A twisted pair was connected from the speaker terminals inside the housing to pins C and D of J103 for test measurements. The speaker monitoring lines were then brought into the test set through the cable harness. This technique also provided easier installation of the test unit in the various environmental chambers. The other change concerned an error in the test procedure. This change applies to paragraph 5.2.9.9. The lamp state for the second test condition in the table should be OFF instead of ON. Also (IDC) should be 0.016 ADC Nom instead of zero.

The test results for the units are very good. The electrical and mechanical design performed to expectations. Only a few minor failures were noted during the environmental tests. The bottom stop on the radio harness vibrated loose during the axis normal to the mounting plate. This was due to a resonance deflection at the center of the harness plate at 38 Hz. A fix was applied which consisted of coating the threads of the thumb screw with "VIBRA-TITE"; which is a reusable, nylon-based thread lock. One coating is sufficient for five or more reinstallations. This fix was considered adequate for the six

development units. A better fastener will be designed for future units.

Another failure was encountered during the ballistic shock test. The M12606-02 speaker magnet separated from its frame and fractured one of the speaker feedthru terminals at the rear of the speaker cavity. The rest of the unit performed within specifications after the test. The speaker was sent to CORADCOM for failure analysis. Recommended corrective action for the speaker design is to require the vendor to build the M12606-02 speaker exactly to the drawing in MIL-L-12606, which utilizes four bolts instead of adhesive to hold the magnet to the speaker frame.

The third and final failure was noted after the 48 hour drying period of the salt-fog test. The bottom stop tether lugs had rusted and slight superficial corrosion and discoloring was noted on the shock mount posts. The unit performed well otherwise. Corrective action will be taken to improve the plating on these items for future units.

VII. RECOMMENDATIONS

One design area where a recommendation for improvement is possibly necessary is the antenna interface. The present interface design is based on the quick portability requirement for the radio set. In other words not having to remove the module cover and adjust the antenna coupler for the portable mode of operation. This quick portability requirement restricts the vehicular antenna interface design and efficiency considerably but will provide short range communications of approximately 1600 yards.

The optimum vehicular antenna interface could be attained by waiving the quick portability requirement and setting the antenna coupler switch to the "0" position for vehicular operation. This position bypasses the antenna coupler and provides a straight thru 50 ohm or 75 ohm interface at the antenna connector on the radio set. The vehicular antenna base assembly would then have to be designed electrically similar to the MX-6707/VRC Matching Unit-Base for the AS-1729/VRC antenna. This matching unit provides nine bandswitched matching positions. The interface between the radio set and antenna base assembly could then be made with any length of RG-58/U or RG-59/U cable. With this efficient matching network in combination with the AT-892 antenna mounted on the cab bulkhead, the communications range between vehicles could be extended to 3 or 4 miles. The matching unit could also be provided with a high/low switch to provide long or short range operation.

The module cover would have to be removed and replaced before the radio set is installed in the Vehicular Applique in order to set the coupler switch to the "0" position. To use the radio set for the

portable mode the procedure is the same except that the antenna coupler is set to the proper switch position and coil setting for the selected operating frequency. The total time to accomplish this procedure is less than five minutes. For most portable applications of the radio set five minutes would probably be insignificant in terms of lost time.

Other recommended or future follow-up redesign areas are the thumb screw fastener for the bottom stop on the radio harness which came loose during vibration and the plating on the tether lugs and shock mount posts.

A recommended design for the M12606-02 speaker, at least for this application, is to require the vendor to build to the configuration shown in MIL-L-12606. This recommended configurated utilizes four bolts instead of epoxy to hold the magnet to the speaker frame. University originally built them to the MIL-L-12606 configuration and were used in the early VRC-12 radios. The bolted configuration would have survived the ballistic shock test. However, the cost of the speaker will probably increase for the recommended configuration. University is no longer on the M12606-02 QPL list.

Incorporation of the GDU Digital Interface is recommended. GDU interface data and an interface circuitry approach have recently been made available to Magnavox engineering. A review of packaging methods indicates that a power-supply compatible version of the circuitry can be added to the present Vehicular Applique units. Only moderate revisions are necessary to provide the very good environmental performance of the units just tested.

APPENDIX A

EQUIPMENT PHOTOGRAPHS

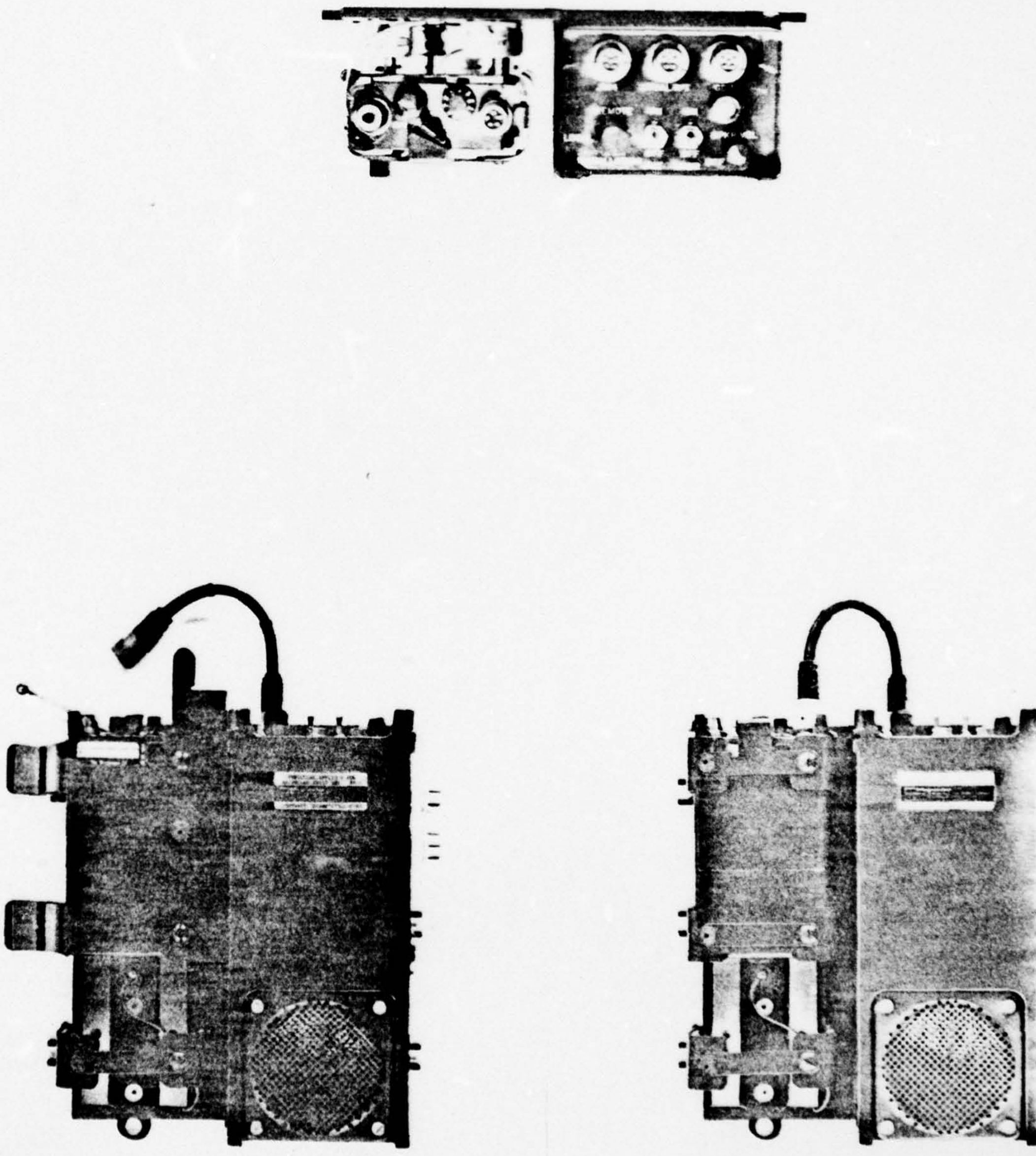


Figure A-1. Vehicular Applique and AN/PRC-68 Radio Set

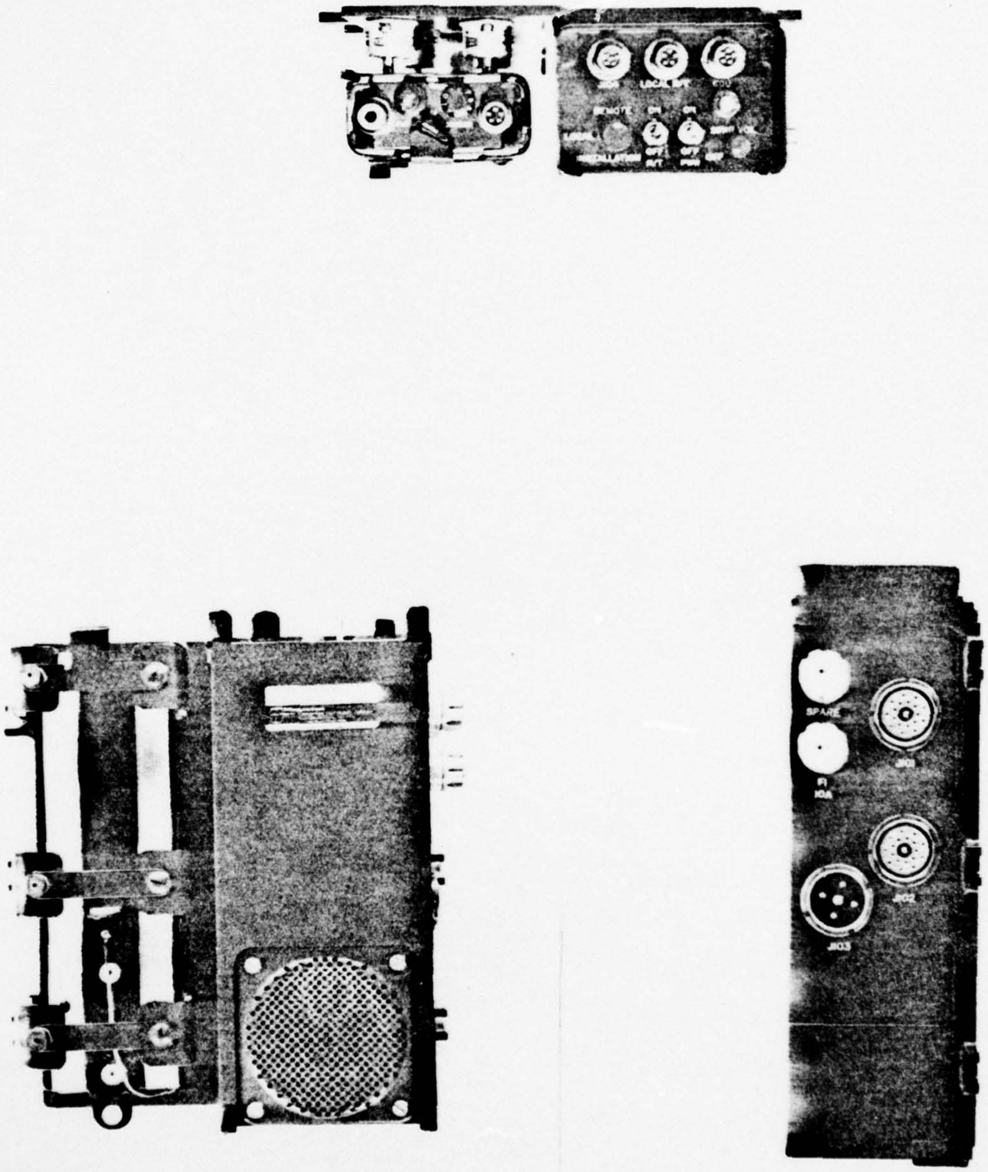
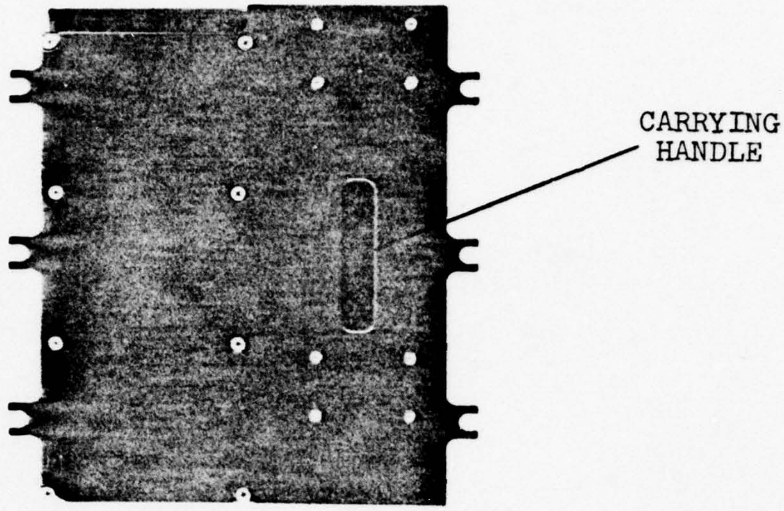


Figure A-2. Vehicular Applique Assembly, 706672-801



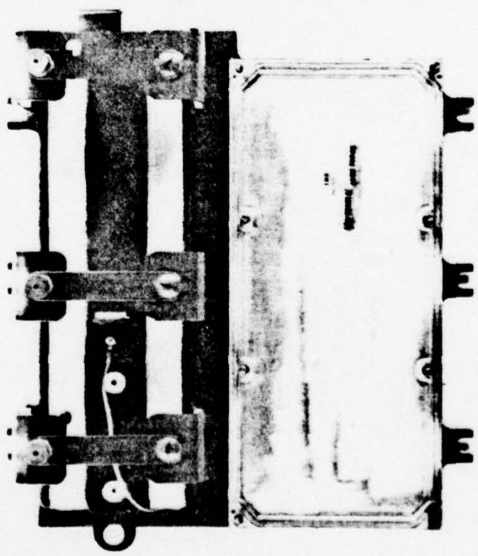


Figure A-3. Mounting Plate Assembly (A20) and Radio Harness Assembly (A50)

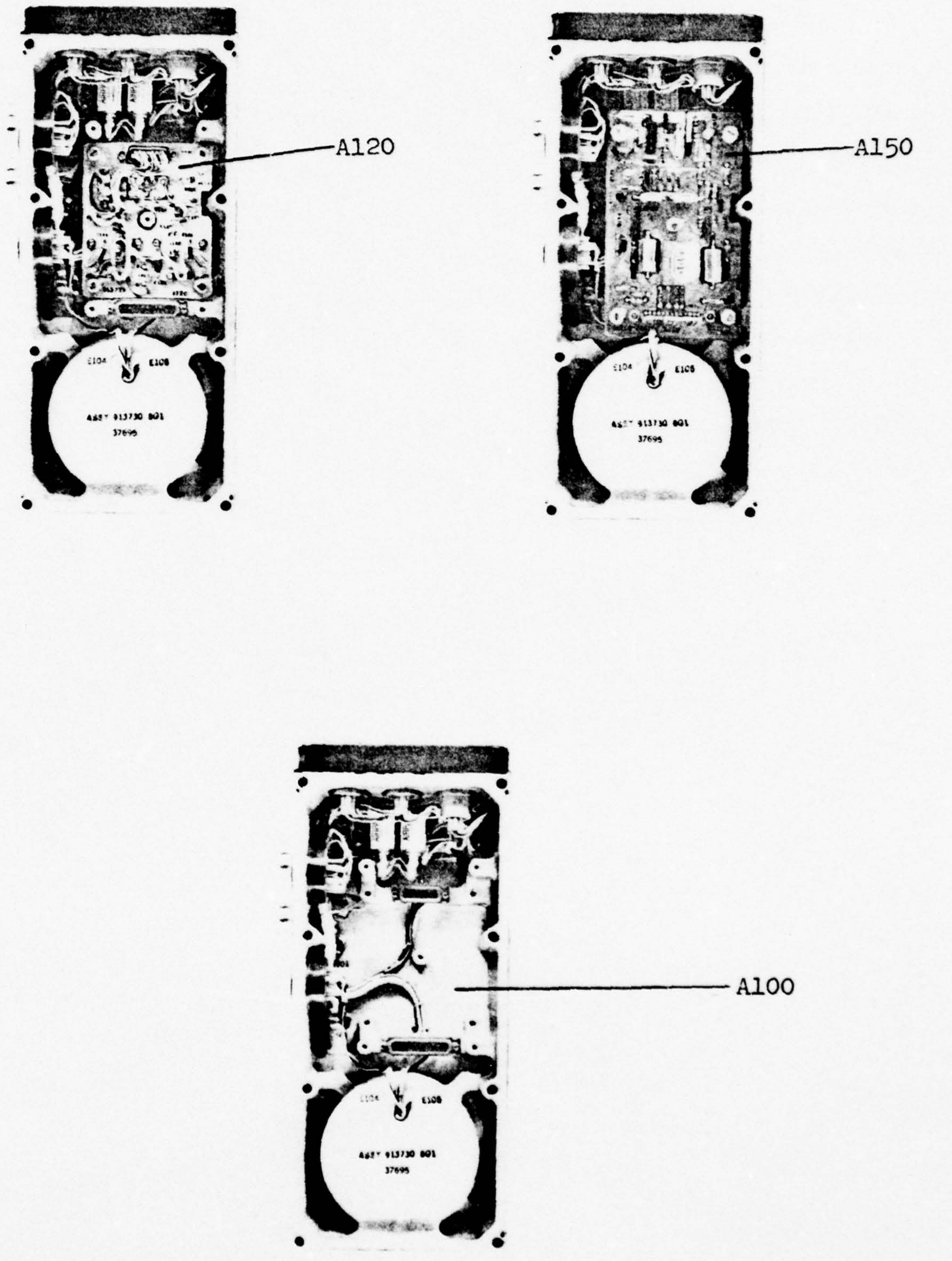


Figure A-4. Housing Assembly (A100)

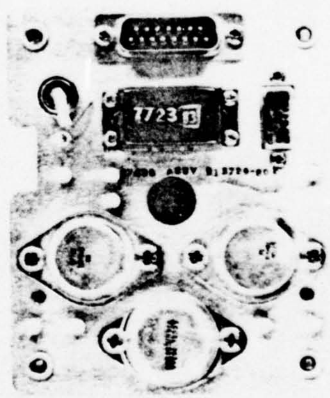
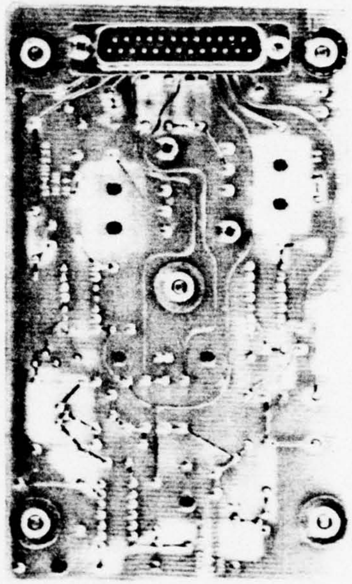


Figure A-5. Power Control Assembly (A120)



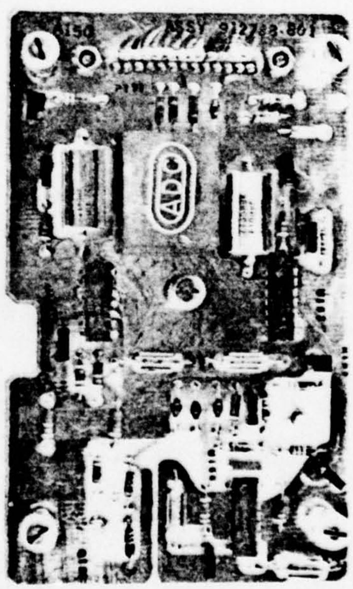
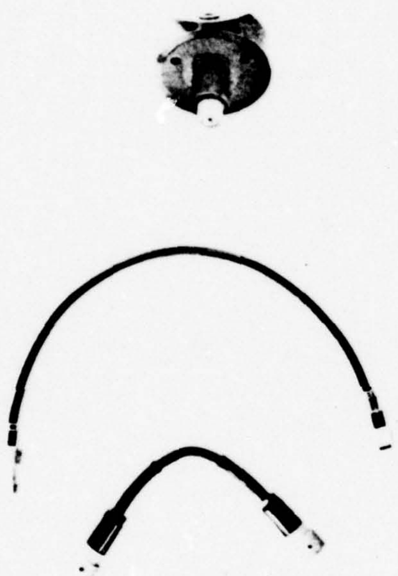


Figure A-6. Audio Amplifier Assembly (A150)



ANTENNA BASE ASSY., 913828-801

ANTENNA CABLE ASSY., 467655-801

INTERFACE CABLE ASSY., 467654-801

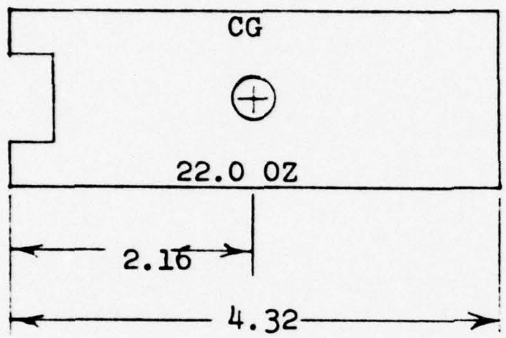
Figure A-7. Ancillary Components

APPENDIX B

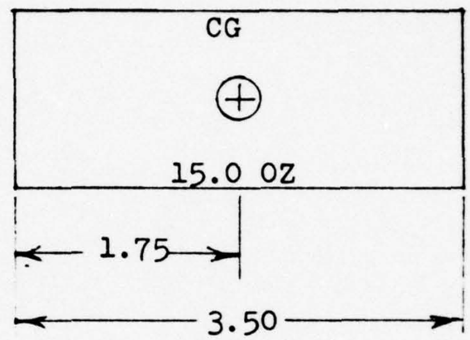
CENTER OF GRAVITY CALCULATIONS

B-1. The following empirical data is used to calculate the combined center of gravity of the R/T module, SVM module, Hg battery, Li battery, and radio mount. Dimensions are in inches.

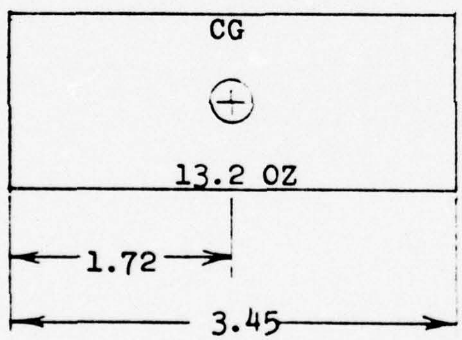
R/T Module



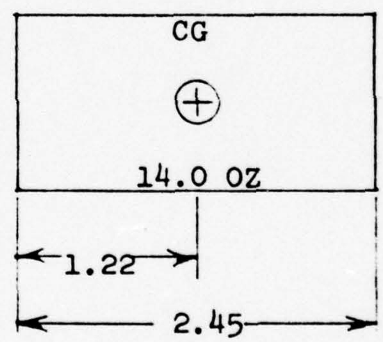
SVM Module



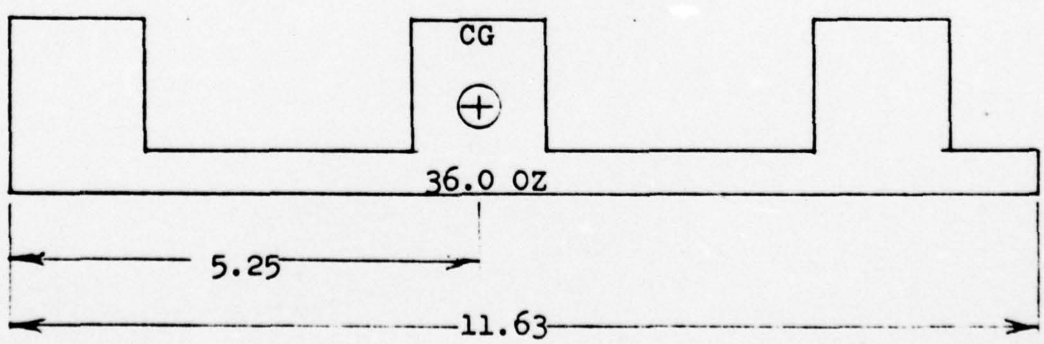
Lithium Battery



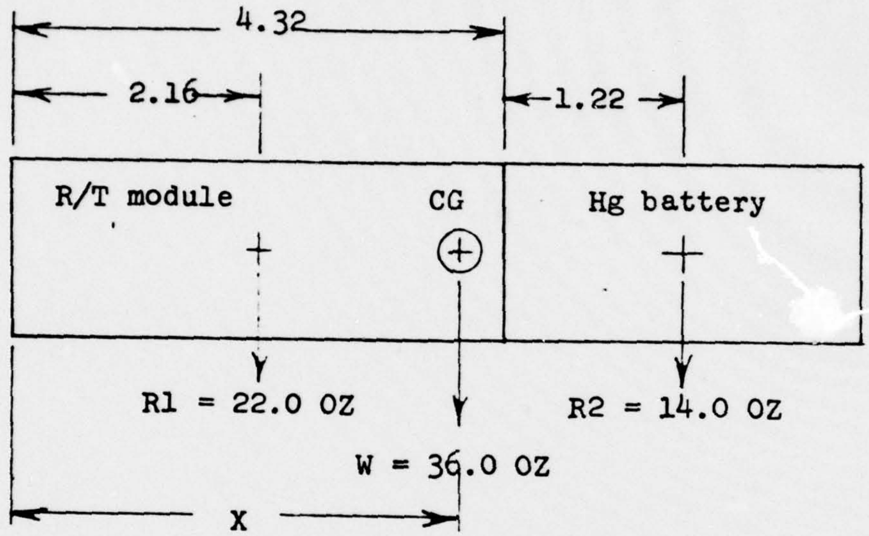
Mercury Battery



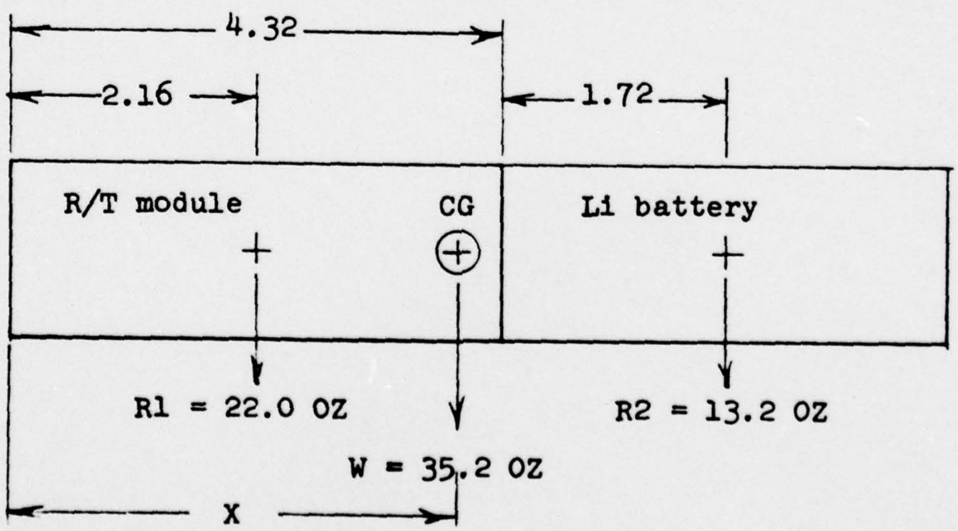
Radio Mount



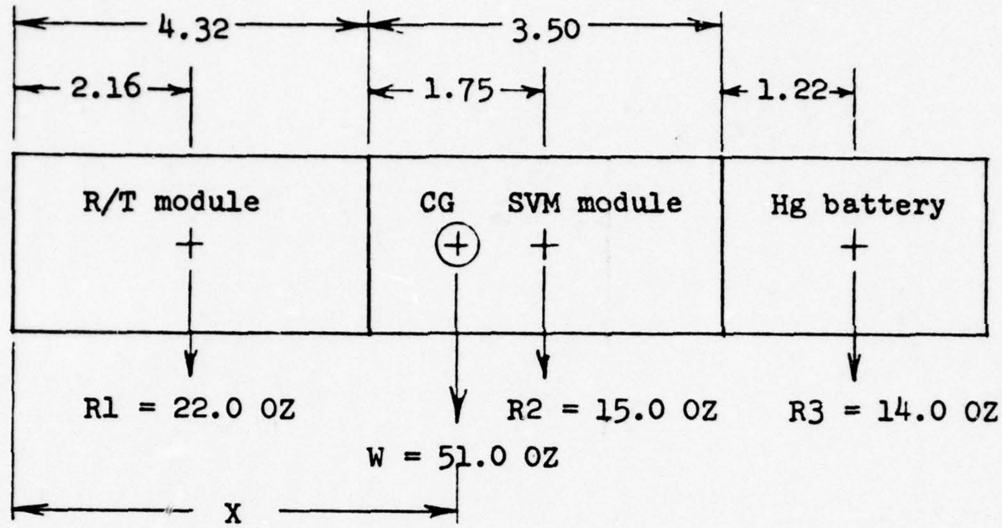
B-2. The combined center of gravity for each radio configuration is found by summing individual C.G.'s as follows:



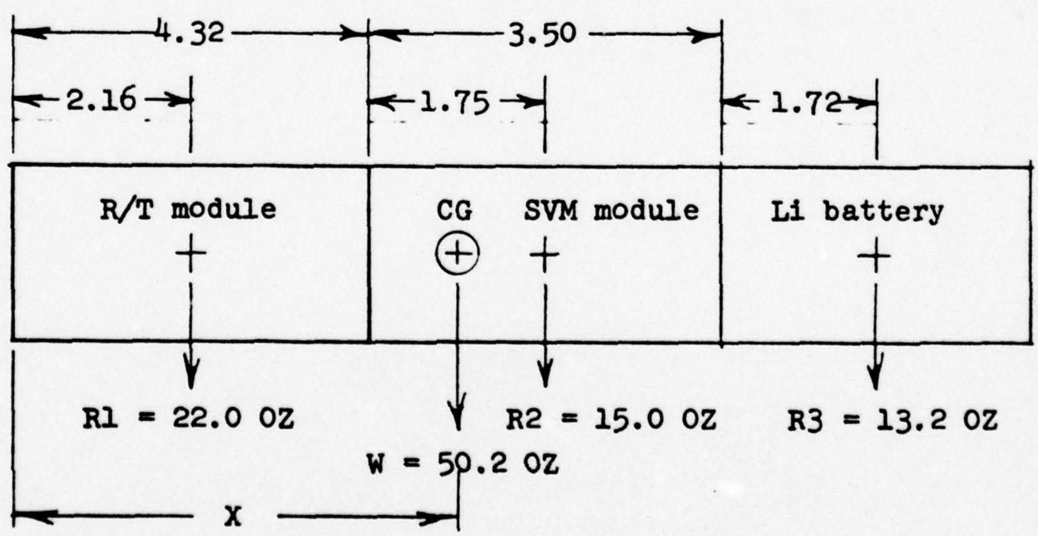
$$R1 (X - 2.16) = R2 (4.32 - X + 1.22) \; ; \; \boxed{X = 3.47}$$



$$R1 (X - 2.16) = R2 (4.32 - X + 1.72) \; ; \; \boxed{X = 3.61}$$



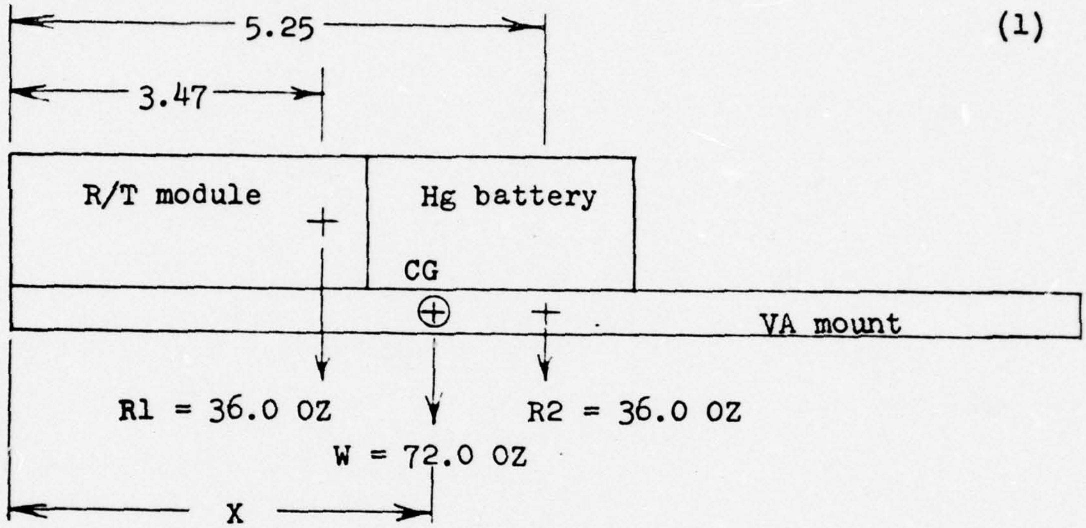
$$R1\ (X - 2.16) = R2\ (1.75 + 4.32 - X) + R3\ (4.32 + 3.50 + 1.22 - X)\ ; \qquad \boxed{X = 5.20}$$



$$R1\ (X - 2.16) = R2\ (4.32 + 1.75 - X) + R3\ (4.32 + 3.50 + 1.72 - X)\ ; \qquad \boxed{X = 5.27}$$

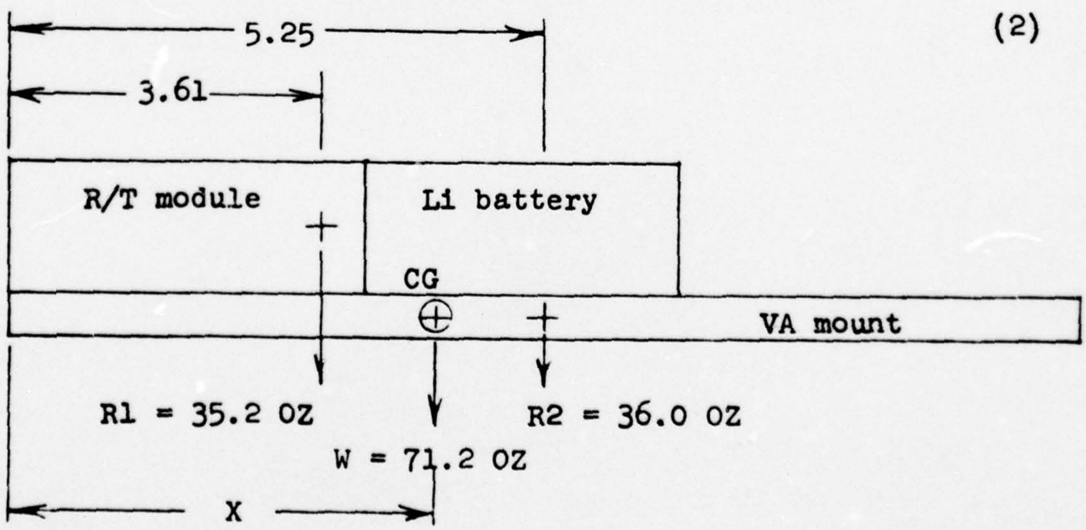
B-3. The combined center of gravity for each radio configuration and the vehicular applique mount (radio harness) is found by summing the individual C.G.'s as follows:

(1)



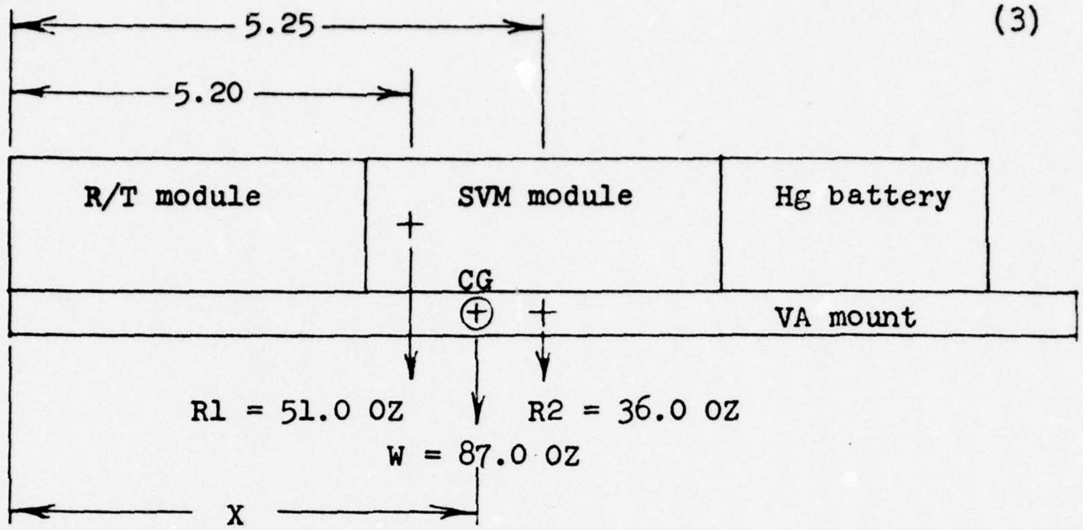
$$R1\,(X - 3.47) = R2\,(5.25 - X)\;; \qquad \boxed{X = 4.36}$$

(2)



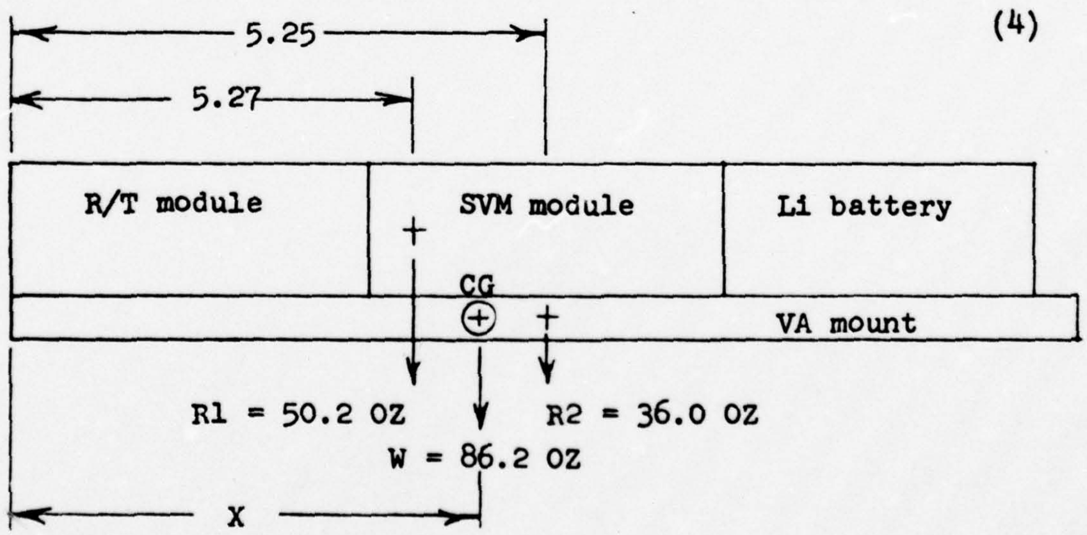
$$R1\,(X - 3.61) = R2\,(5.25 - X)\;; \qquad \boxed{X = 4.44}$$

(3)



R1 (X - 5.20) = R2 (5.25 - X) ; $\boxed{X = 5.22}$

(4)



R1 (X - 5.27) = R2 (5.25 - X) ; $\boxed{X = 5.26}$

B-4. The composite center of gravity is the average of the four values of X calculated in paragraph B-3.

$$\text{Composite C.G.} = \frac{X(1) + X(2) + X(3) + X(4)}{4}$$

$$= \frac{4.36 + 4.44 + 5.22 + 5.26}{4}$$

Composite C.G. = 4.82 inches

APPENDIX C. INSTALLATION DIAGRAM

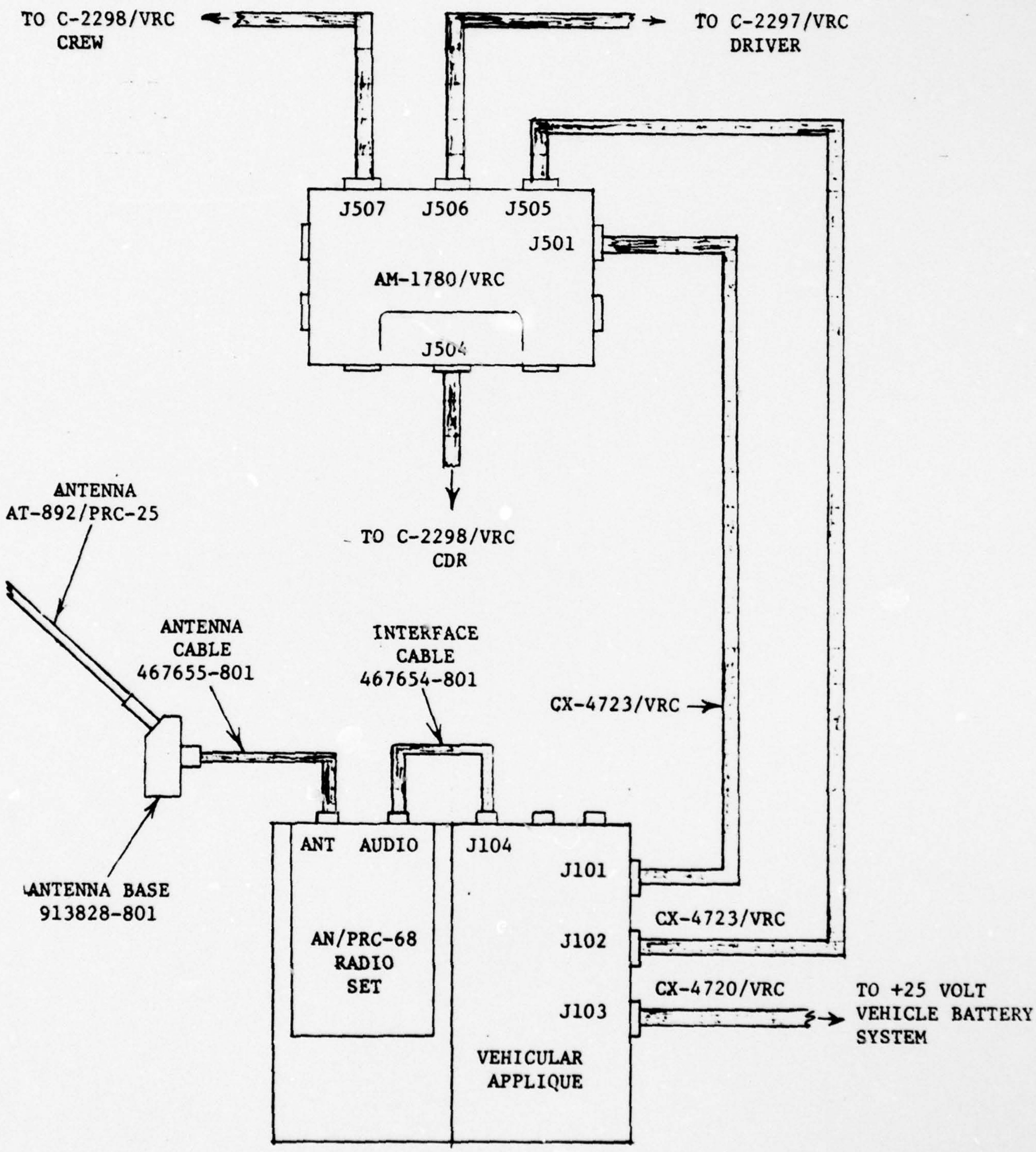


Figure C-1. Cabling of Vehicular Applique with AN/PRC-68 and Radio-Intercom System.

APPENDIX D

SCHEMATIC DIAGRAMS

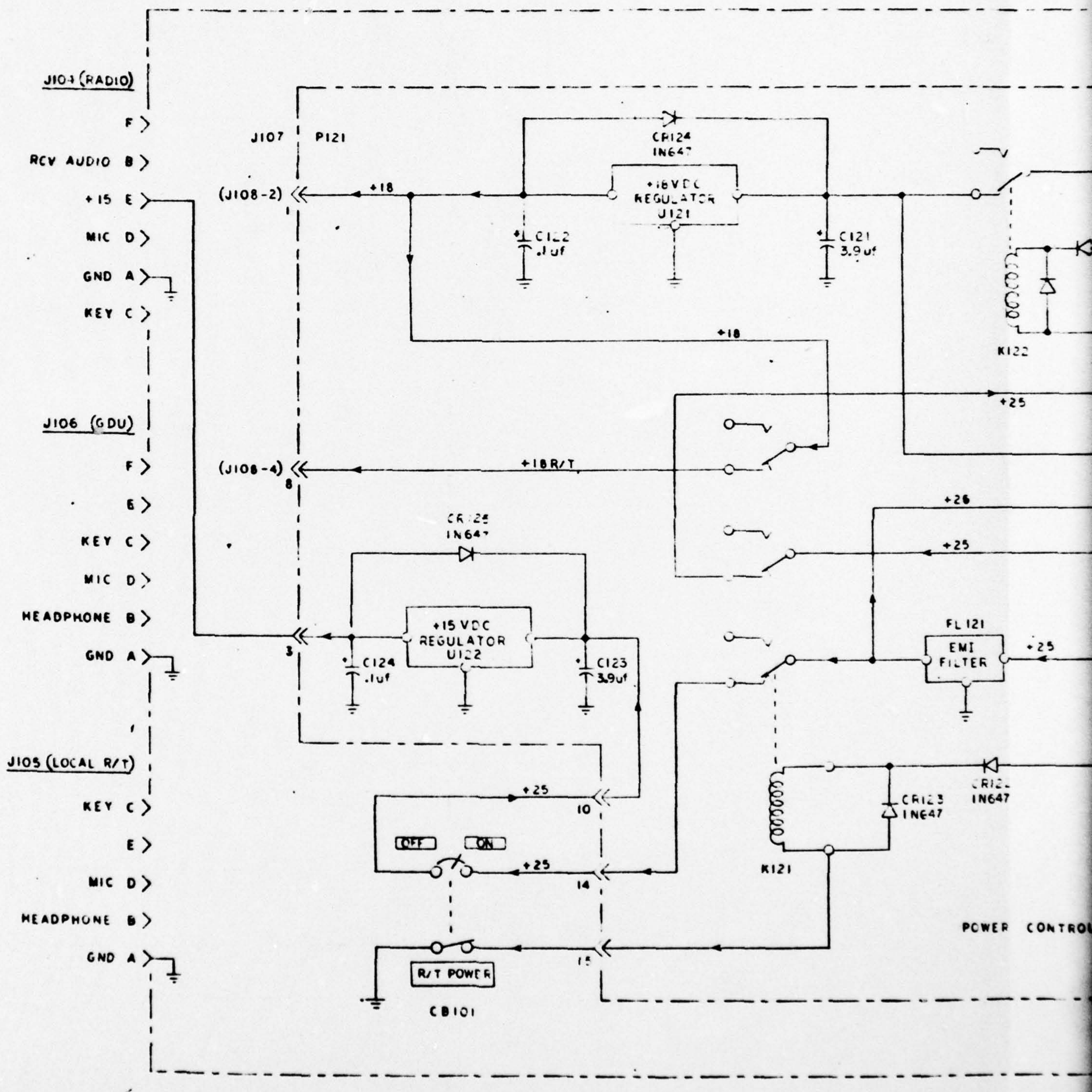
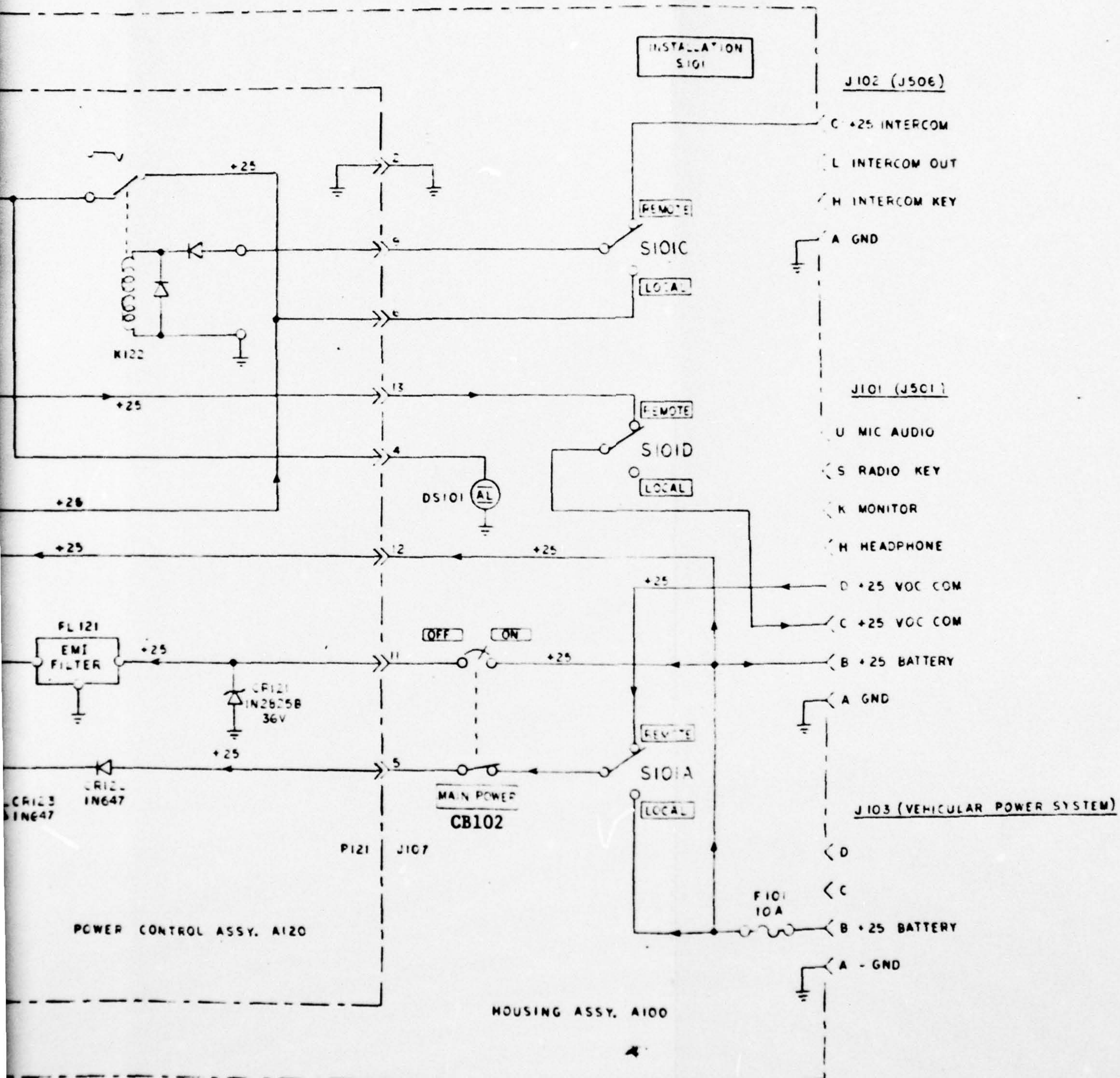


Figure D-1. Vehicular Applique, dc power and control circuits.


INSTALLATION S101
J102 (J506)
C +25 INTERCOM
L INTERCOM OUT
H INTERCOM KEY
A GND
REMOTE
S101C
LOCAL
K122
+25
J101 (J501)
U MIC AUDIO
S RADIO KEY
K MONITOR
H HEADPHONE
D +25 VOC COM
C +25 VOC COM
B +25 BATTERY
A GND
REMOTE
S101D
LOCAL
DS101
AL
FL 121
EMI FILTER
CR121
IN2825B
36V
OFF
ON
MAIN POWER
CB102
S101A
CR122
IN647
CR123
IN647
P121
J107
J103 (VEHICULAR POWER SYSTEM)
D
C
F101
10A
B +25 BATTERY
A - GND
POWER CONTROL ASSY. A120
HOUSING ASSY. A100

circuits.

2

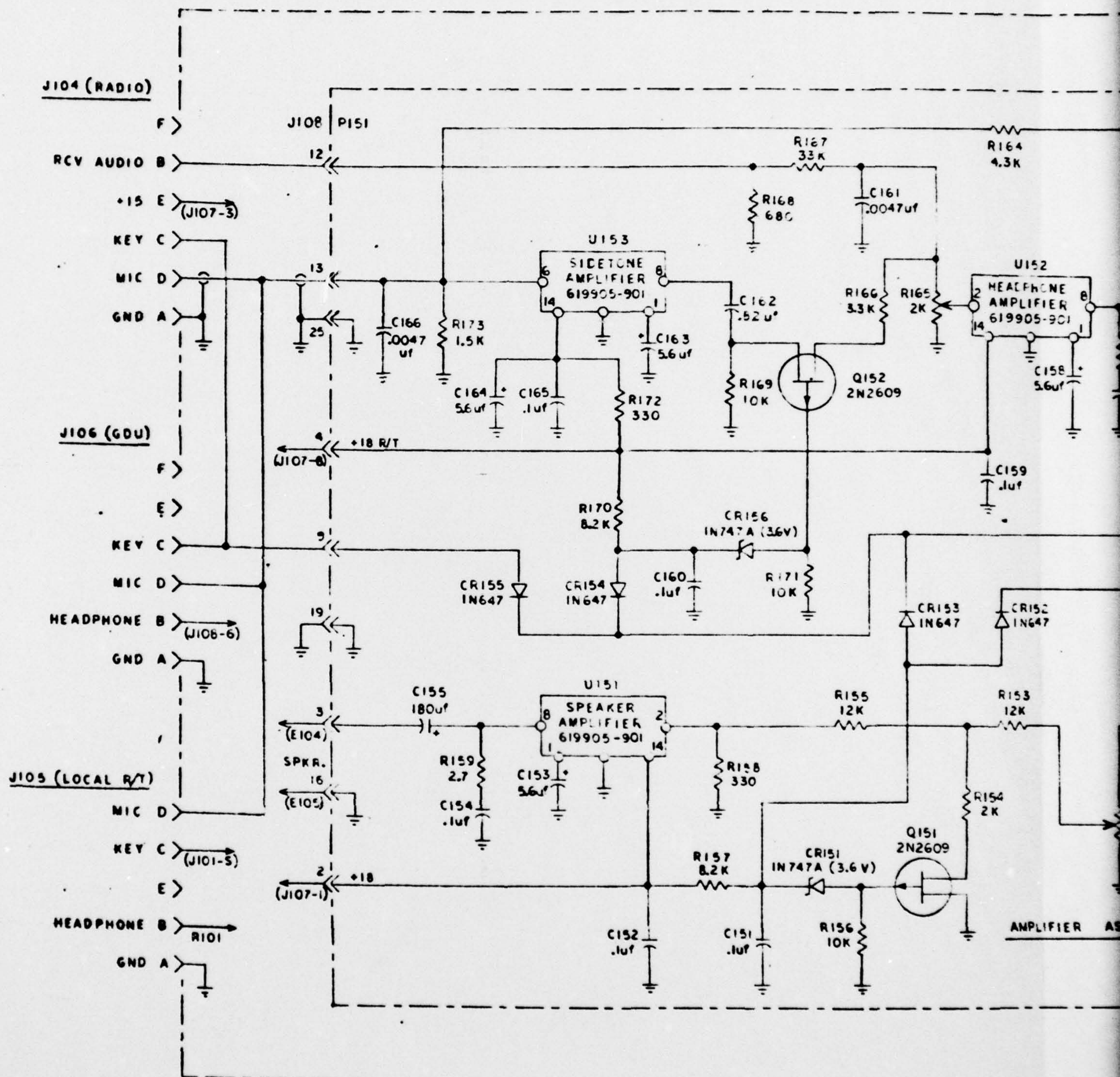
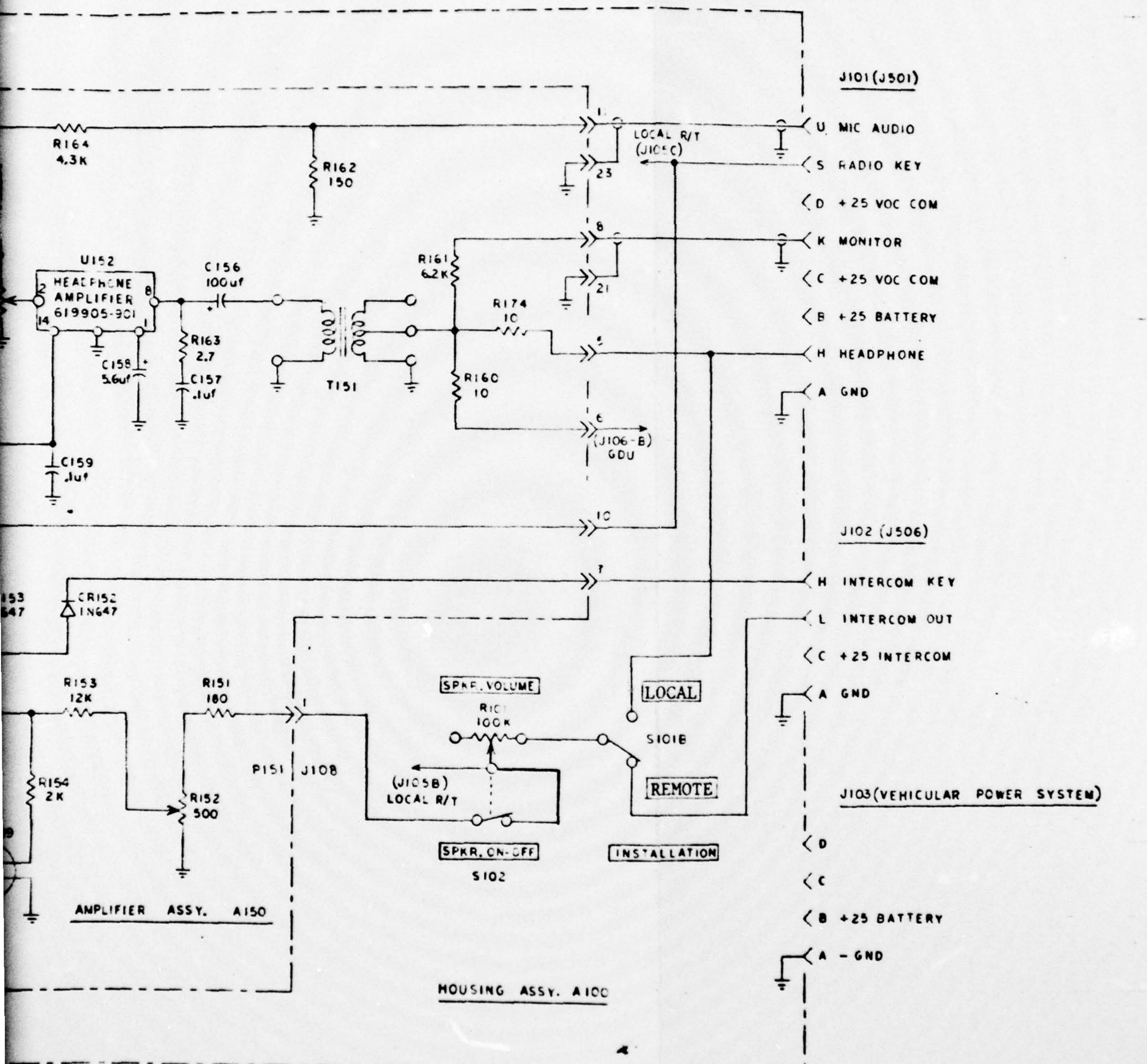


Figure D-2. Vehicular Applique, audio and keyline circuits.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U MIC AUDIO
S RADIO KEY
D +25 VDC COM
K MONITOR
C +25 VDC COM
B +25 BATTERY
H HEADPHONE
A GND
J102 (J506)
H INTERCOM KEY
L INTERCOM OUT
C +25 INTERCOM
A GND
J103 (VEHICULAR POWER SYSTEM)
D
C
B +25 BATTERY
A - GND
R164 4.3K
R162 150
LOCAL R/T (J105C)
U152
HEADPHONE AMPLIFIER 619905-901
C156 100uf
R161 6.2K
R174 10
R163 2.7
C158 5.6uf
C157 .1uf
T151
R160 10
(J106-B) GDU
C159 .1uf
CR152 1N647
R153 12K
R151 180
SPKR. VOLUME
R101 100K
LOCAL
S101B
REMOTE
P151 J108
R154 2K
R152 500
(J105B) LOCAL R/T
SPKR. ON-OFF
S102
INSTALLATION
AMPLIFIER ASSY. A150
HOUSING ASSY. A100

uits.

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